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METAVERSE LANDSCAPE & OUTLOOK SERIES

METAVERSE DECODED BY TOP EXPERTS

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METAVERSE

Preface to the Metaverse...

Yu Yuan and **Steve Mann**, June 14, 2022

It has been 30 years since the term "metaverse" was coined by Neal Stephenson in his 1992 science fiction novel Snow Crash [1], and 48 years since S. Mann invented, and coined the term, "metavision" as extended reality using wearable computing [2].

Meta is a magic word that inspires infinite imaginations of countless people from various professions and backgrounds. It is also an ancient Greek word that means "beyond" in a self-referring sense, e.g. a meta-conversation is a conversation about conversations, and metadata is data about data (e.g. the header information in a photo that tells us when and where it was taken). Thus the metaverse is a universe of universes, i.e. the ultimate universe, and metavision is the vision of vision, e.g. the sensing of senses, and thus the ultimate sensory experience -- extended reality and extended intelligence.

The metaverse will have a profound impact on our daily work, play, and life, across all industries and sectors, and on the economy and deconomy (inverse economy), reshaping society for all humankind. Metaverse and Sustainability are complementary to each other, and will be the two mega themes in the coming decades. The Sustainability of the Metaverse will require a concern not only for the Environment (that which surrounds us) but also for the "Invironment" (ourselves, i.e. the human element). In this sense the Metaverse is inextricably intertwined with the Vironment (the interplay and boundary between humans and their surroundings), i.e. space in which humans can interact with computer-generated content and with other humans, i.e. "Humanistic Intelligence / Integration" (HI or "Hint") [3, 4, 5]. Whereas the Metaverse calls to mind a community of "cyborgs" using technology to interact with cyborgspace and each other, the concept of "cyborg" is more than a million years old [6], and thus what is new with is the means with which we will interact with our technological universe and each other in an immersive space [6].

Preface to the Metaverse... (cont.)

In order to provide a comprehensive and authoritative global view, 11 top experts who have been deeply engaged in the metaverse field for many years (although perhaps we have not labeled our work as "metaverse" before) share key points and insights on the metaverse in this report, including:

- The definition of the metaverse
- The concepts that are currently labeled as the metaverse but are not actually the metaverse
- The biggest technical challenge in creating a true metaverse
- The most noteworthy risk in the metaverse from an ESG perspective
- The sign that the metaverse is really facing an explosive growth in business
- The predicted impact of the metaverse on each industry
- The market potential and time to market of each application scenario of the metaverse

This report is the first installment of the Metaverse Landscape and Outlook series. We hope it will be helpful within and outside the metaverse industry. Please stay tuned for our series of future reports.

References:

[1] Stephenson, N. "Snow Crash, Bantam." New York (1992).

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[5] Chen, Quan Ze, et al. "HINT: Integration Testing for AI-based features with Humans in the Loop." 27th International Conference on Intelligent User Interfaces. 2022.

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2022 METAVERSE ELEVEN

TOP EXPERTS

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IEEE Standards Association
Co-founder, VerseMaker

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"Father of Wearable Computing"
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"Grandfather of Virtual Reality"
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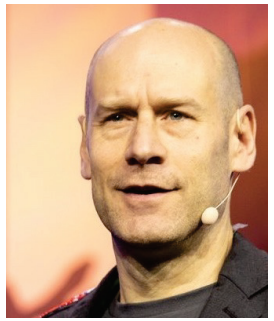

Ori Inbar

Co-founder & CEO,
Augmented World Expo

Matthew Ball

CEO of Epyllion, a Metaverse-
focused holding company
Widely acclaimed Metaverse
thought leader

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SECTION 01

HIGHLIGHTS

Key points on the metaverse

Named after the universe, a metaverse shall be **persistent,** and should be **massive, comprehensive, immersive, and self-consistent.** Described with "meta", a metaverse should be ultra-realistic, accessible, pervasive, and may be decentralized. In a narrow sense, metaverse may be simply defined as **Persistent Virtual Reality (PVR).** In a broad sense, metaverse is **the advanced stage and long-term vision of Digital Transformation.**

—— **Yu Yuan** (President-Elect, IEEE Standards Association / Co-founder, VerseMaker)

The fake metaverse has seen an explosion of hype, but the true metaverse is just waiting to surface. The biggest technical challenges are in the development of wearable AI technology, and particularly solving **the collinearity problem and the photoquantigraphic alignment as well as keeping everything in the same orbit.**

—— **Steve Mann** ("Father of Wearable Computing" / Professor, University of Toronto)

The metaverse is an **unprecedented multidimensional and multisensory communication and transactional medium** that is globally distributed. We may need to be thinking of what is the update to the VRML that is friendly to multi-sensory and motor response integration needed in virtual environments, so **standards will be essential.**

—— **Thomas A. Furness III** ("Grandfather of Virtual Reality" / Professor, University of Washington)

I think the metaverse idea and enthusiasm comes from **making the internet support live communication,** with other people **always present** when you are using it. I think it is both more complex and difficult to achieve without causing harm to people.

—— **Philip Rosedale** (Founder, Linden Lab / Second Life)

It is impossible to predict with certainty what form the metaverse will take in the longer term as it will evolve as the result of **a chaotic Darwinian process** selecting for successful technologies, products, and experiences.

—— **Neil Trevett** (President, Khronos Group / VP of Developer Ecosystems, NVIDIA)

Simulation brings enormous opportunity for all enterprises as simulating projects **thousands of times virtually before producing in reality will save on cost and waste, and increase operational efficiency and accuracy.**

—— **Rev Lebaredian** (VP of Omniverse & Simulation Technology, NVIDIA)

The metaverse is **the next evolution in social technologies.**

—— **Caitlin Kalinowski** (Head of AR Hardware, Meta)

In our own universe the visible matter makes up less than **5 percent** of the mass of the universe. It is the same for the metaverse. **The dark matter of the metaverse is the compute, data, and intelligence that make it all work.**
The biggest challenge the metaverse is facing is a massive flow of data from the real world into the metaverse and back into the real world. It is this flywheel of data that will enable continuous improvement to the metaverse experience. It is also this flywheel that will have a profound impact on the real world.

—— **Danny Lange** (Senior VP of AI, Unity)

The biggest challenge is that the metaverse environment **depends upon other critical and complex technologies to exist -- in order to have life.**

—— **Evelyn R. Miralles** (Former NASA Chief Engineer & VR/AR Pioneer / Board Member, Speaker & Consultant)

The challenge is **bringing all the pieces together in a somewhat homogeneous environment** that allows discovery, navigation, identity, and user experience to be consistent such as it is across most of the internet today.

—— **Ori Inbar** (Co-founder & CEO, Augmented World Expo)

Blockchains, Web3, decentralization, virtual worlds like Roblox or Minecraft, video games. These are technologies, philosophies, organizational structures, 3D platforms, and games. They are **relevant to the Metaverse, but calling them the Metaverse is like calling HTML the Internet, an app the Internet, Facebook the Internet,** etc.

—— **Matthew Ball** (CEO of Epyllion, a Metaverse-focused holding company / Widely acclaimed Metaverse thought leader)

SECTION 02

EXPLAINING THE METAVERSE

Hottest questions about the metaverse

SECTION 02

What IS the metaverse?

What is your definition of the metaverse?

Metaverse may refer to a kind of experiences in which the outside world is perceived by the users (human or non-human) as being a universe that is actually built upon digital technologies as a **different universe ("Virtual Reality"), a digital extension** of our current universe **("Augmented Reality" or "Mixed Reality"),** or **a digital counterpart** of our current universe **("Digital Twin").** Named after the universe, a metaverse shall be **persistent,** and should be **massive, comprehensive, immersive, and self-consistent.** Described with "meta", a metaverse should be **ultra-realistic, accessible, pervasive, and may be decentralized.** In a narrow sense, metaverse may be simply defined as **Persistent Virtual Reality (PVR).** In a broad sense, **metaverse is the advanced stage and long-term vision of Digital Transformation.**

—— **Yu Yuan** (President-Elect, IEEE Standards Association / Co-founder, VerseMaker)

Metaverse can be described as an all computer-generated or synthetic world, accessible via immersive technologies such as virtual reality, where humans can independently participate and interact with others and the environment around them.

—— **Evelyn R. Miralles** (Former NASA Chief Engineer & VR/AR Pioneer / Board Member, Speaker & Consultant)

I like the simplest definition: **the next generation of the internet which is Spatial (or embodied) .**

—— **Ori Inbar** (Co-founder & CEO, Augmented World Expo)

SECTION 02 THE DEFINITION OF THE METAVERSE

DEFINITION:

The metaverse is meta-sensory XR (eXtended Reality), i.e. metaveillance or metavision.

RELATED CONCEPT = Web 3.0:
In the early 2000s, I coined the term "Web3.0" as "cyborgspace", i.e. XR (eXtended Reality) space in which users can interact with computer-generated content and other users. Mark Lipton, Professor at University of Guelph, tweeted about my Web 3.0 work on Nov 12, 2010: "#DIY10 Steve Mann "Web 3.0 is the new deconomy"; What would Jenkins say? 9:38 AM · Nov 12, 2010", and in more recent years many people are using this term in the context of the metaverse.

This concept of Web 3.0 was further expanded upon by Mann, Michael, Janzen, et. al., as a theme in the IEEE ISTAS 2013 conference call-for-participation, as published in University of Toronto Engineering News, Feb. 5th, 2010: https://news.engineering.utoronto.ca/potential-perils-wearable-technology/

ORIGINS OF THE METAVERSE IN THE 1970s:
But the metaverse concepts really go back a lot earlier. In 1974, I invented the SWIM = Sequential Wave Imprinting Machine which was a wave computation system for interactively exploring wave propagation in air, water, or solid matter. SWIM allowed a person to see and interact with not only radio waves and sound waves, but also the capacity of devices to sense radio waves or sound waves.

For example, in the 1970s, I was able to see and photograph a radar or sonar's capacity to sense, as well as see and photograph a microphone's capacity to sense sound waves, and a camera's capacity to sense. I coined and defined the terms **Metavision, Meta-sensing, Metaveillance, Metaveillography, and Metaveillogrammetry,** in regards to this sensing of sensors (radar, sonar, microphones, cameras, etc.) and the sensing of their capacity to sense. Collectively, these concepts define what I regard as the metaverse.

META FOUNDED IN 2013:
In 2013 we founded a company called Meta, based on my Metavision and Metaveillance concepts, to make "Extramissive spatial imaging digital eye glass" technology, invented by Gribetz and Mann, originally filed with the US Patent and Trademark office Jan 3, 2013, as US Patent and Trademark Office, Patent Application 61/748,468, Jan 3, 2013, which eventually led to our patent, US Patent 9,720,505, "Extramissive spatial imaging digital eye glass...", Gribetz; Meron (New York, NY), Mann; W. Steve G. (Toronto, CA) , filed January 3rd, 2014.

My general idea of Metaveillance and Metavision was in the spirit of sousveillant systems, which forms the basis for HI = **Humanistic Intelligence**: Mann, Steve. "Humanistic computing:" WearComp" as a new framework and application for intelligent signal processing." Proceedings of the IEEE 86.11 (1998): 2123-2151, online at: http://wearcam.org/hi.pdf leading to a paper by Marvin Minsky, Ray Kurzweil, and myself (Steve Mann), Minsky, Marvin, Ray Kurzweil, and Steve Mann. "The society of intelligent veillance.“ 2013 IEEE International Symposium on Technology and Society (ISTAS): Social Implications of Wearable Computing and Augmediated Reality in Everyday Life. IEEE, 2013, which is also online at: http://wearcam.org/sensularity.pdf

The best embodiment of the metaverse is through wearable AI as defined in "Wearable AI", authors=Mann, Steve and Li-Te Cheng and John Robinson and Kaoru Sumi and Toyoaki Nishida and Soichiro Matsushita and Ömer Faruk Özer and O˘guz Özün and C. Öncel Tüzel, and Volkan Atalay and A. Enis Çetin and Joshua Anhalt and Asim Smailagic and Daniel P. Siewiorek and Francine Gemperle and Daniel Salber and Sam Weber and Jim Beck and Jim Jennings and David A. Ross, Intelligent Systems, IEEE, volume 16, number 3, pages 1-53, May/June 2001
See http://wearcam.org/wearableai.pdf

See also the concept of Steveland in Canadian Patent 2357697 (CA2357697A1).

—— **Steve Mann** (“Father of Wearable Computing” / Professor, University of Toronto)

SECTION 02 THE DEFINITION OF THE METAVERSE

The short answer is that **the metaverse is a modern transportation system for connecting the minds and hearts** of the worlds citizens. The longer answer separates the question into two parts: the first part is what it is, that is, what are the configurations of technology that make it possible; whereas the second part deals with what it does, or what is its functionality.

In terms of what it is, the metaverse is an unprecedented multidimensional and multisensory communication and transactional medium that is globally distributed. It is a confluence, integration and melding of converging technologies including wireless telecommunications (e.g. the internet), extended reality (including virtual, augmented and mixed realities), spatial computing, artificial intelligence/machine learning, a digital medium of valuate exchange (e.g. blockchain, etc.) and digital assets that include virtual worlds, NFTs, simulations and knowledge bases.

In terms of what it does, the metaverse allows participants to occupy common virtual 3D spaces (e.g. virtual worlds) from anywhere in the physical world, wherein they can learn, training, design, conduct business, receive diagnosis and therapy and engage in entertainment activities. The metaverse overcomes the tyranny of distance in allowing participants to be in a place and interact in that space with others without moving their bodies to that place. The incorporation of immersive virtual worlds effectively activates spatial memory that in turn prolongs retention of experiences and what has been learned. The virtual places can be derived from scanning physical spaces or constructed via artistic or other design/worldbuilding activities. The metaverse also will allow people to look remotely through eyes of other people to gain their perspectives of what they see physically. There are unlimited applications that can be implemented via the 'messages' that are delivered by the 'medium' of the metaverse. The most exciting aspect of the metaverse is emergence of these new applications of how it can be used. The great hope is that the metaverse can unlock human intelligence and link minds so as to address globally the pervasive problems of our civilization.

—— **Thomas A. Furness III** ("Grandfather of Virtual Reality" / Professor, University of Washington)

SECTION 02

THE DEFINITION OF THE METAVERSE

I think the metaverse idea and enthusiasm comes from two different areas of innovation:

1. Making the internet and websites **3D versus 2D.**
2. Making the internet support **live communication,** with other people **always present** when you are using it.

Of these two, I think the second is both more complex and difficult to achieve without causing harm to people. So, to me, the 'metaverse' is best captured as the idea of online spaces where people are able to gather and communicate in groups.

—— **Philip Rosedale** (Founder, Linden Lab / Second Life)

It is impossible to predict with certainty what form the metaverse will take in the longer term as it will evolve as the result of **a chaotic Darwinian process** selecting for successful technologies, products, and experiences. But the inspiration to work towards the larger vision of a widely accessible, spatial successor to today's Web will create a 'wavefront' of shorter-term innovations and opportunities along the path to whatever form the metaverse eventually takes. There will be a single metaverse, just as there is a single World Wide Web, a connective foundation hosting a diversity of products, environments, and experiences. **If the metaverse is to be open, it will need to be based on open interoperability standards that no single company controls - just like the Web.**

—— **Neil Trevett** (President, Khronos Group / VP of Developer Ecosystems, NVIDIA)

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THE DEFINITION OF THE METAVERSE

The metaverse is a concept, the next evolution of the internet, the extension of physical and virtual worlds. We see the Metaverse as an evolution of the Internet and World Wide Web. It's a 3D embodied Web, where we can connect inside virtual worlds that look and feel to us as rich and complex as the real world.

—— **Rev Lebaredian** (VP of Omniverse & Simulation Technology, NVIDIA)

The metaverse is the next evolution in social technologies. Instead of a specific digital place, the Metaverse is conceptually a way to embody shared information–what we currently call the internet, and are experiencing in 2D. More practically, the Metaverse will be a set of digital spaces, including immersive 3D experiences, that are interconnected so you can easily move between them. It will let you do things you couldn't do in the physical world, and with people you can't physically be with. In the metaverse, you'll be able to do almost anything you can imagine—get together with friends and family, work, learn, play, shop, create—as well as completely new experiences that don't really fit how we think about computers or phones today.

—— **Caitlin Kalinowski** (Head of AR Hardware, Meta)

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THE DEFINITION OF THE METAVERSE

The metaverse is a self-referential abstraction of the real world that we live in, also known as the universe. Consider the metaverse a multi-modal fabric that provides seamless integration between the virtual world and the real world. As a user of the metaverse, you can move between virtual worlds and the real world in an asynchronous fashion. While the real world is bound by the physical constraints of space and time, the metaverse is completely free from these constraints. **Space is malleable and time becomes relative** allowing you to explore the past, present, and future. If you think this all sounds a bit out of the ordinary then just think about a robotics or autonomous vehicle simulator. The metaverse is already very real.

—— **Danny Lange** (Senior VP of AI, Unity)

The Metaverse is a massively scaled and interoperable network of real-time rendered 3D virtual worlds which can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments.

—— **Matthew Ball** (CEO of Epyllion, a Metaverse-focused holding company / Widely acclaimed Metaverse thought leader)

SECTION 02

What IS NOT the metaverse?

Which concepts do you think are currently labeled as the metaverse but are not actually the metaverse, or are not the core elements of the metaverse?

NFT is not the metaverse, nor a core element or a necessary element of the metaverse. It can serve some useful purposes in the metaverse, such as incentivizing content creators, but exaggerating its role is harmful. In particular, we have seen lots of misleading and confusing propaganda that couldn't wait to add a metaverse label on NFTs that have no use value but only the so-called collection value or investment value. Collecting and investing are only a small part of our real life today and will be the same in the metaverse in the future. **The mainstream demand of mankind for the metaverse will never be collection and investment.**

Web3 is not the metaverse either. A metaverse may be decentralized in terms of infrastructure or application scenarios, but it does not have to be. From both the technical perspective and the business perspective, there can be centralized metaverses, which in many aspects can do better than decentralized metaverses. Web3 advocates like to talk about ownership, but **what really matters to users is use and service, not ownership.** Today, it is increasingly being advocated that even transportation should be a shared service that does not require everyone to own a private vehicle, so why should everyone own a portion of the Internet or the metaverse? In particular, we need to be wary of rip-offs in the name of decentralization. What is concealed under the banner of decentralization could be the centralization of wealth to a small group of speculators.

Given that NFT and Web3 have become too dominant in the metaverse-related public opinion field, it is necessary to reiterate: **NFT and Web3 are neither the metaverse nor the necessary elements of the metaverse. They are no more than optional elements that may be useful to the metaverse in some cases.**

—— **Yu Yuan** (President-Elect, IEEE Standards Association / Co-founder, VerseMaker)

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WHAT ARE INCORRECTLY LABELED AS THE METAVERSE

The word "metaverse" has become over-used. I think that systems that **lack sousveillance should not be considered to belong to the metaverse** because they lack a closed-loop feedback that is a necessary element, i.e. take a look at the fractal nature of HI and Metavision/Metaveillance, Mann, Steve, Cayden Pierce, Aman Bhargava, Christopher Tong, Khantil Desai, and Kyle O'Shaughnessy. "Sensing of the Self, Society, and the Environment." In 2020 IEEE SENSORS, pp. 1-4. IEEE, 2020.

See http://wearcam.org/ieeesensors2020/IEEE_Sensors_Sensing_Self_Technology_Society_and_Environment/PID6605899.pdf

Clearly if there is no sousveillance there is no feedback loop and therefore no metaverse.

—— **Steve Mann** (“Father of Wearable Computing” / Professor, University of Toronto)

SECTION 02

WHAT ARE INCORRECTLY LABELED AS THE METAVERSE

The metaverse is not just the internet on steroids, it is a whole new way of how humans will communicate and conduct their everyday lives. **Right now is it a catch all moniker...but it also doesn't have any limits.** So I not sure that this is a viable question until the dust settles.

—— **Thomas A. Furness III** ("Grandfather of Virtual Reality" / Professor, University of Washington)

I don't think that connecting different game environments together with standard protocols is the metaverse. **I also don't think that cryptocurrency or NFTs are very closely related to the metaverse, although they may play some role.**

—— **Philip Rosedale** (Founder, Linden Lab / Second Life)

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WHAT ARE INCORRECTLY LABELED AS THE METAVERSE

Virtual Reality will be widely used in the metaverse to participate in diverse experiences. However, the rich diversity of 'spatial Web' use cases means that VR will be just one way to access metaverse functionality. In addition to VR-based immersiveness in constructed worlds, Augmented Reality will connect the physical and virtual in ways that could be far more relevant to most people's everyday lives, plus the metaverse will often be accessed through the flat screens of phones, tablets, and PCs. So, **the concept that is hopefully NOT central to the metaverse is a future where society disconnects from reality, through dystopian immersion in virtual environments such as portrayed in popular culture such as Ready Player One.**

—— **Neil Trevett** (President, Khronos Group / VP of Developer Ecosystems, NVIDIA)

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WHAT ARE INCORRECTLY LABELED AS THE METAVERSE

The term Metaverse is a broad description of the collection of the many types of virtual worlds we will see as an evolution of the web as we know it today. We can play, socialize, work and create inside the Metaverse as if we are in the space together, despite being separated by great distances in real the world. These virtual worlds can cover many types of use cases across all types of industries from entertainment to industrial and design - provided there is a common connection between these worlds in much the same way that HTML connects all websites with consistent experiences of images, text and videos. Many of the broadly celebrated use cases are focused on extended reality (XR). We understand that this is just one way to experience a virtual world, but it is not the only way. Just like the majority of gamers experience 3D worlds (games) today on 2D devices, **we understand majority of virtual world users will use their workstations, laptops, mobile devices to portal into virtual world.**

—— **Rev Lebaredian** (VP of Omniverse & Simulation Technology, NVIDIA)

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WHAT ARE INCORRECTLY LABELED AS THE METAVERSE

There's a misconception that the metaverse will be a singular experience. For example, like it's just VR or it's just AR. But that's not accurate. **The metaverse will be a combination of immersive technology that's interconnected, not separate.** When you enter a social VR space, or play a VR game today, you're not in a true metaverse. But these experiences do offer glimpses of what will be possible once the connective tissue – the technologies and platforms that need to be built to connect many different worlds together into the metaverse – come to life.

—— **Caitlin Kalinowski** (Head of AR Hardware, Meta)

The metaverse is too often thought of as an all-encompassing user experience with VR goggles or not yet available smart glasses. The user experience of the metaverse is much more diverse than that. **In our own universe the visible matter makes up less than 5 percent of the mass of the universe. It is the same for the metaverse. The dark matter of the metaverse is the compute, data, and intelligence that make it all work.**

—— **Danny Lange** (Senior VP of AI, Unity)

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WHAT ARE INCORRECTLY LABELED AS THE METAVERSE

VR, MR, AR are not the core elements of the metaverse.

—— **Evelyn R. Miralles** (Former NASA Chief Engineer & VR/AR Pioneer / Board Member, Speaker & Consultant)

Because many view it as the next generation of the internet - the metaverse has become the catch-all term for everything about the future. And in some way it's true, so I do not see much value in trying to define what's in or out of it. I think what's important is to think through how all digital (and real) experiences today could benefit from becoming spatial.

—— **Ori Inbar** (Co-founder & CEO, Augmented World Expo)

Blockchains, Web3, decentralization, virtual worlds like Roblox or Minecraft, video games games. These are technologies, philosophies, organizational structures, 3D platforms, and games. **They are relevant to the Metaverse, but calling them the Metaverse is like calling HTML the Internet,** an app the Internet, Facebook the Internet, etc.

—— **Matthew Ball** (CEO of Epyllion, a Metaverse-focused holding company / Widely acclaimed Metaverse thought leader)

SECTION 02

The CHALLENGE of Metaverse

What do you think is the biggest technical challenge in creating a true metaverse? When do you expect a breakthrough?

From the technical perspective, there are two grand challenges in creating a true metaverse.

One is **how to achieve comprehensive and ultra-realistic virtual senses and actions.** For example, when we can simulate not only the look, smell, and taste of beer, but also the dopamine and pleasure produced after drinking alcohol. The breakthrough in this direction will come from brain-machine interface, and I expect it will take more than 10 years.

The other is **how to build a large-scale, fine-grained, persistent, and physically self-consistent virtual world.** For example, when a lake in a virtual world can not only glint like water, but also be so fine-grained that every virtual water molecule conforms to physical laws. Whether boating on the lake, jumping into it for swimming, or washing your face with a handful of water, the interaction between virtual water and other virtual objects can be completely in line with physical laws such as fluid mechanics, and even physicists can't find any flaws to tell that this is a virtual world. The breakthrough in this direction depends on the continuous progress in computing, storage, engine, modeling and other technologies. I expect it will take about 5 years.

—— **Yu Yuan** (President-Elect, IEEE Standards Association / Co-founder, VerseMaker)

SECTION 02

THE BIGGEST TECHNICAL CHALLENGE IN CREATING A TRUE METAVERSE

The biggest technical challenges are in the development of wearable AI technology, and in particular solving the collinearity problem as outlined in Chapter 3 of the textbook, Mann, Steve. Intelligent image processing. John Wiley & Sons, Inc., 2001. and the photoquantigraphic alignment outlined in Chapter 4, as well as keeping everything in the same orbit as in Chapter 6.
We expect the EyeTap criteria (Chapter 3) to come to breakthrough level around 2025, and the other two problems to be solved a little earlier.

—— **Steve Mann** ("Father of Wearable Computing" / Professor, University of Toronto)

We don't need any breakthrough in technology to begin implementing the metaverse. Certainly a browser based ubiquitous cross platform functionality is needed that is standardized to accommodate various headsets and other viewing platforms. We may also need to be thinking of **what is the update to the VRML that is friendly to multi-sensory and motor response integration needed in virtual environments. So standards will be essential.**

—— **Thomas A. Furness III** ("Grandfather of Virtual Reality" / Professor, University of Washington)

There are two big challenges:
1.Making online communication good enough to be acceptable to most people, particularly when in groups. Avatars, for example, are not yet acceptable to most people as a replacement for themselves in normal social interactions.
2.Large numbers of people together as avatars in large environments. **The scaling problems to support a useful number of people together in the same place have not yet been solved.**

—— **Philip Rosedale** (Founder, Linden Lab / Second Life)

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THE BIGGEST TECHNICAL CHALLENGE IN CREATING A TRUE METAVERSE

Multi-player games are pioneering many metaverse-related technologies, but gaming servers typically support just dozens of simultaneous users in a single environment. It will be a significant challenge to scale the number of simultaneous users in a metaverse world to thousands or even millions of users. Portability of objects and avatars between different metaverse worlds will be enabled through cross-platform asset standards. Widely deployed standards such as glTF are actively upgrading from '3D asset formats' that define an object's appearance through geometry, textures and animations, to 'metaverse asset formats' that add attributes and properties to define how an object behaves when placed within an environment. **It will be a significant challenge to define and encapsulate sophisticated attributes and properties to enable flexible and convincing behavior of complex objects across diverse environments.**

—— **Neil Trevett** (President, Khronos Group / VP of Developer Ecosystems, NVIDIA)

The full vision of the metaverse can't happen without a lot of technical innovation. We need to see a steep increase in access to hardware and significant improvements in connectivity across the world, **especially wireless technologies and internet backhaul improvements.** We will need to deliver AR and VR head-mounted devices that folks are comfortable wearing for longer amounts of time, and display technologies that optimize resolution and immersion. All this won't be built overnight, instead we'll see the metaverse and technologies that fuel it over the next 10-15 years.

—— **Caitlin Kalinowski** (Head of AR Hardware, Meta)

SECTION 02

THE BIGGEST TECHNICAL CHALLENGE IN CREATING A TRUE METAVERSE

One thing that is essential for all of these worlds is them to have a common foundation for how they are presented, experienced and most importantly, connected. Omniverse is a platform that connects virtual worlds and is built on USD (Universal Scene Description) which can be thought of as the HTML of 3D. Omniverse can be connected to from most of the industries leading 3D software products, it can be extended, and applications can be built on this platform using an integrated SDK called Kit. Simulating high-fidelity virtual worlds is an incredibly challenging problem. It's actually an infinite problem. We can always throw more computing power at making our virtual worlds bigger, more complex and more rich. But there's more to it than just that: There are two big problems NVIDIA is focused on for Omniverse virtual worlds

- Making it easy for everyone to participate in the creation of high-fidelity virtual worlds
- Scaling true to reality simulation of virtual worlds efficiently to computers in the data center and the cloud

The web is successful because virtually anyone can make a web page and participate in the construction of the ever expanding web. 3D content for virtual worlds is much harder to create today -- it requires great expertise, so only a small group of elite game and 3D artists can do this today. With advanced computing, simulation, computer vision and AI, we are building the tools to enable greater numbers of people to participate in building high-fidelity virtual worlds.
The other big problem is simulating large complex worlds. Today, virtually all game engines are limited to running one computer (gaming console, PC, mobile device, …). If you want to simulate a larger world with more fidelity, you can't throw more computers at it to make it faster. With the cloud, we now have that computing power available to us in the data center, but scaling 3D world simulation past one node is an unsolved problem we are aiming to address.
We now have the technology to create true-to-reality digital twins of the physical world and this new evolution of the web will be much larger than the physical world because like the web, almost every industry will benefit from participating and hosting virtual worlds. Creators will make more things for virtual worlds than they do in the physical world, enterprises will build countless digital twins of products, environments and spaces - from object scale to planetary scale. **Simulation brings enormous opportunity for all enterprises as simulating projects thousands of times virtually before producing in reality will save on cost and waste, and increase operational efficiency and accuracy.** Omniverse is a technology layer focused on connecting and building physically accurate virtual worlds or "digital twins" to help solve the world's hardest engineering and science problems.

—— **Rev Lebaredian** (VP of Omniverse & Simulation Technology, NVIDIA)

SECTION 02

THE BIGGEST TECHNICAL CHALLENGE IN CREATING A TRUE METAVERSE

To fully reap the benefits of the metaverse it has to exist in a seamless integration with the real world. **The biggest challenge the metaverse is facing is a massive flow of data from the real world into the metaverse and back into the real world. It is this flywheel of data that will enable continuous improvement to the metaverse experience. It is also this flywheel that will have a profound impact on the real world.** Let's get back to the autonomous vehicle simulator which is used to improve the control system of the vehicle. By collecting real world data for the vehicle, we can feed the experience back into the simulation to minimize the reality gap. Even by today's standards, we are unable to collect and transport all the data that is needed for this. Shortcomings in IoT, networks, connectivity, storage, and compute compound this problem.

—— **Danny Lange** (Senior VP of AI, Unity)

The biggest challenge is that the metaverse environment **depends upon other critical and complex technologies to exist -- in order to have life.** The other big challenge is cybersecurity concerns.

—— **Evelyn R. Miralles** (Former NASA Chief Engineer & VR/AR Pioneer / Board Member, Speaker & Consultant)

SECTION 02

THE BIGGEST TECHNICAL CHALLENGE IN CREATING A TRUE METAVERSE

The rise of the Metaverse term did a great service to promoting AR and VR to the mainstream, but it also made things that are being done today - feel too futuristic. In other words - many pieces of the metaverse are already here today! **The challenge is bringing all the pieces together in a somewhat homogeneous environment that allows discovery, navigation, identity, and user experience to be consistent** such as it is across most of the internet today. Many developers and organizations are already working on defining the standards that will allow that consistency across the future metaverse and as these processes take time - we may see the fruits in several years (5-10).

—— **Ori Inbar** (Co-founder & CEO, Augmented World Expo)

Computing power and network latency. I do not expect a "breakthrough", but instead progressive improvements.

—— **Matthew Ball** (CEO of Epyllion, a Metaverse-focused holding company / Widely acclaimed Metaverse thought leader)

SECTION 02

IV

The RISKS of Metaverse

From an ESG (Environmental, Social, and Governance) perspective, what do you think is the most noteworthy risk in the metaverse?

I think the most noteworthy risk in the metaverse lies **in personal identity. How to make sure your avatar will not be copied or used without your authorization? How can you tell if a person you meet in the metaverse is being manipulated by the real person in oneself ?** These issues may have significant negative ethical and social impacts, and must be resolved by a series of standards and regulations.

—— **Yu Yuan** (President-Elect, IEEE Standards Association / Co-founder, VerseMaker)

The biggest risk is surveillance. The problem is that there are driving commercial and governance thrusts toward more surveillance without a balanced amount of sousveillance. This creates a broken feedback loop as per the fractal (self-similar) nature of the metaverse outlined in the 2020 IEEE Sensors paper referenced above.

The problem also is the nexus of Covernments (corporate governments) and Gorporations (Government corporations) pushing for more surveillance, working together for increased surveillance and increased privacy, which we have shown is itself another form of surveillance. See "Privacy is Surveillance", https://medium.com/@mann_86448/privacy-is-surveillance-8e7478ac77aa

For the metaverse to function there needs to be a good amount of equiveillance (equilibrium and balance between surveillance and sousveillance).

—— **Steve Mann** ("Father of Wearable Computing" / Professor, University of Toronto)

SECTION 02

THE MOST NOTEWORTHY RISK IN THE METAVERSE FROM AN ESG PERSPECTIVE

The ultimate objective is to do no harm. **Since there is deep coupling of user sensory, perceptual and cognitive functions and psyche in the metaverse, security and safety are major concerns.** It is also critical to investigate the longitudinal effort of extended use of VR headsets in the virtual world.

—— **Thomas A. Furness III** ("Grandfather of Virtual Reality" / Professor, University of Washington)

There are tremendous risks. Two in particular:
Moderation: If centralized moderation is applied to public online spaces, there is great risk of harm to people, for example through homogenizing behavior and opinions to simplify moderation costs. Online spaces could continue to polarize people to dislike each other and gradually reduce diversity of behavior and opinion.
The risk that we 'give up' on problems like climate change and wealth inequality, choosing instead to escape to virtual worlds.

—— **Philip Rosedale** (Founder, Linden Lab / Second Life)

It is a significant potential risk that **the immersive and pervasive nature of the metaverse may exacerbate negative aspects of today's social media.** Also, the nature of wearable XR displays that track so many aspects of a user and their surroundings also presents a clear risk of reduced privacy and security.

—— **Neil Trevett** (President, Khronos Group / VP of Developer Ecosystems, NVIDIA)

THE MOST NOTEWORTHY RISK IN THE METAVERSE FROM AN ESG PERSPECTIVE

NVIDIA is focused on building enabling technologies for the builders of virtual worlds for industrial use cases, we are not building social media experiences or platforms.

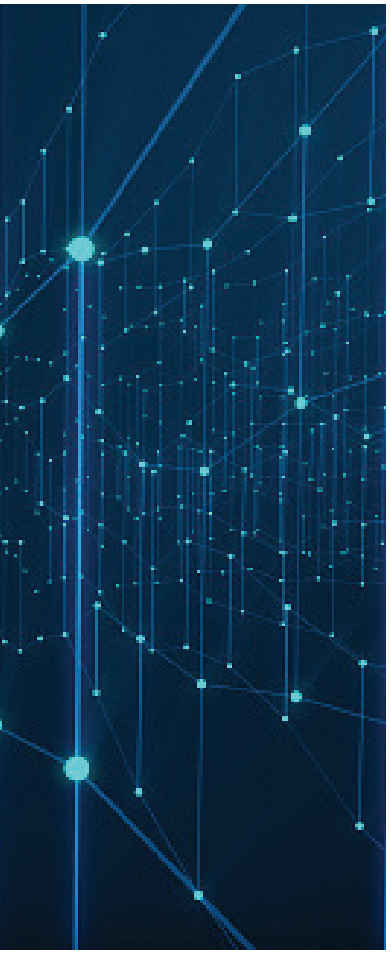
—— **Rev Lebaredian** (VP of Omniverse & Simulation Technology, NVIDIA)

I consider the metaverse a huge positive for ESG. The metaverse allows us to explore and design the future in a much more sustainable way than how we have done it in the past. We can verify designs before they are actually built in the real world and we can visit places without physically traveling. Of course, we have to ensure that the metaverse is equitable with ample opportunities for all. **While I do not want to trivialize the goal of making the metaverse productive for all I believe it generally lowers the barrier for participation.**

—— **Danny Lange** (Senior VP of AI, Unity)

SECTION 02

THE MOST NOTEWORTHY RISK IN THE METAVERSE FROM AN ESG PERSPECTIVE



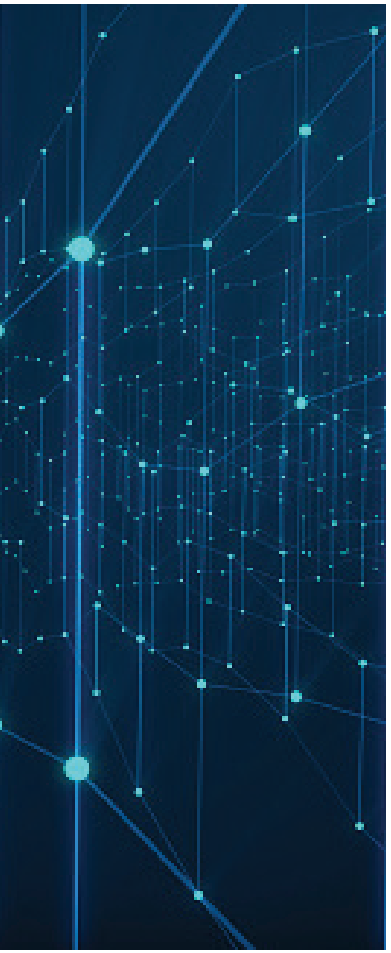
The metaverse isn't a single product one company can build alone, it will require interoperability and collaboration with industry partners, civil rights groups, governments, nonprofits, and academics on how to build these technologies responsibly. And that's why we're having conversations about the metaverse out in the open way in advance of all these technologies being launched. This way, everyone will be able to ask the right questions and help inform the process along the way.

Protections also need to be built in from the start, not retrofitted at the end. Realistically, we won't be able to see around every corner. That's why the principles of privacy, safety and security need to be built in from the very beginning. If we have the principles right, then as a society we will be better at tackling new challenges with these technologies as they arise.

—— **Caitlin Kalinowski** (Head of AR Hardware, Meta)

SECTION 02

THE MOST NOTEWORTHY RISK IN THE METAVERSE FROM AN ESG PERSPECTIVE



The biggest risk is **mind control tendencies, coupled with privacy and cybersecurity risks,** that could lead to lasting unexpected and not positive societal implications.

—— **Evelyn R. Miralles** (Former NASA Chief Engineer & VR/AR Pioneer / Board Member, Speaker & Consultant)

The cultural backlash is the biggest risk facing the Metaverse. In a spatial environment user tracking issues become exponentially more problematic. Will the future "citizens" of the metaverse feel safe and secure? Will they revolt about Spatial interactions that expose them to hazards more than anything we have ever seen? Of course the biggest threat facing humanity in the next few decades is climate change and the **worldwide use of the Metaverse could both help in that fight (reduced travel, reduced manufacturing waste) as well as exacerbate the situation with significant increase in energy consumption (data farms are expected to reach 8-10% of the global energy use by 2030.)**

—— **Ori Inbar** (Co-founder & CEO, Augmented World Expo)

The fact that the Metaverse will exacerbate many unsolved ESG problems of the current era, from misinformation to data rights, data security, abuse and harassment, happiness, platform power, etc.

—— **Matthew Ball** (CEO of Epyllion, a Metaverse-focused holding company / Widely acclaimed Metaverse thought leader)

SECTION 02

V

The SIGN that the metaverse is exploding

What do you think is the sign that the metaverse is really facing an explosive growth in business? Has it already appeared, or when will it appear?

I don't think there will be any clear sign between now and an explosive growth of the metaverse industry. **The growth of the metaverse industry is likely not to have an explosive stage, but rather a gradual progression like a "slow bull run" or a "harvesting while plowing" journey.** The metaverse is a fundamental and disruptive innovation that will bring significant and far-reaching influences and even revolutions to all industries and sectors. But if we look back at several other fundamental and disruptive innovations in recent years, such as cloud computing, big data, and the Internet of Things, it is difficult to tell when they quietly became ordinary in our work and life. While none of these innovations may be comparable to the metaverse from any perspective, **I choose to believe that the road to the metaverse will be a road that requires patience to climb but is very scenic and rewarding along the way.**

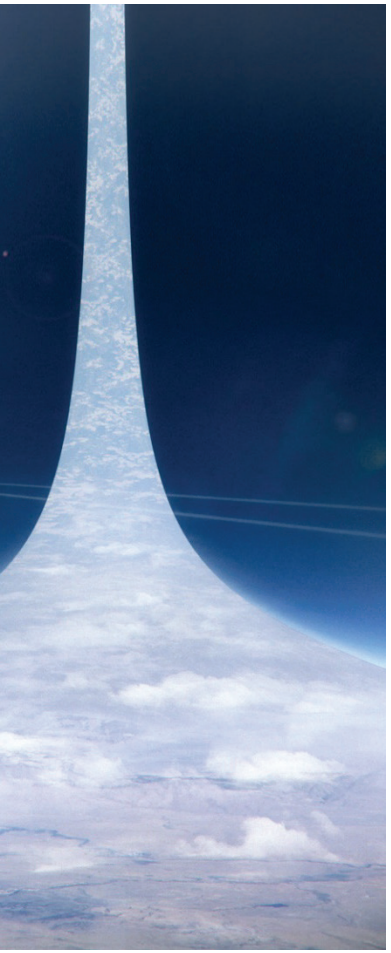
—— **Yu Yuan** (President-Elect, IEEE Standards Association / Co-founder, VerseMaker)

The fake metaverse has seen an explosion of hype, but the true (i.e. sousveillant or metaveillant) metaverse is just waiting to surface and when it does, it will be really amazing.

—— **Steve Mann** (“Father of Wearable Computing” / Professor, University of Toronto)

SECTION 02

THE SIGN THAT THE METAVERSE IS FACING AN EXPLOSIVE GROWTH



It is already happening. Lots of position papers and books being written.

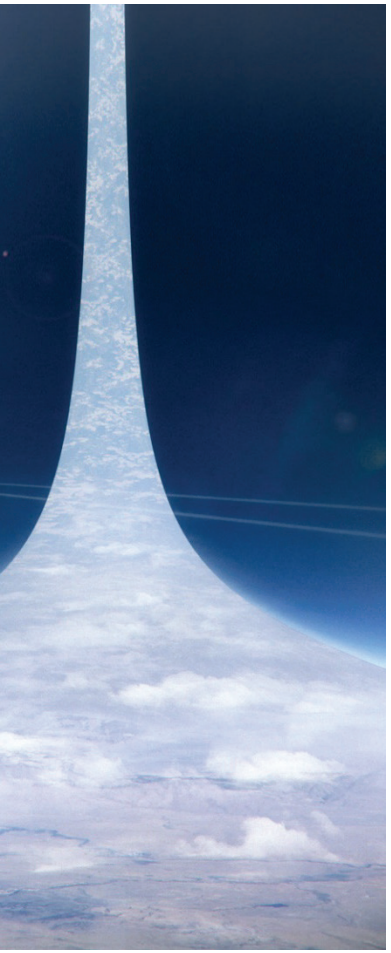
—— **Thomas A. Furness III** (“Grandfather of Virtual Reality” / Professor, University of Washington)

It is unlikely that ‘the metaverse’ will abruptly appear as a fully formed product or market, it will instead deploy incrementally over time as technical innovations and business models are proven, and interoperability standards are created to enable scaling to pervasive scale. Many companies and standards organizations are investing today in initiatives to make the building blocks that will be needed to deploy the broad vision of a spatial web, while reaping the benefits of intermediate use cases that become enabled. As with many disruptive changes, **the metaverse will probably take longer than we expect to materialize - but will have a larger impact than we expect when it does.**

—— **Neil Trevett** (President, Khronos Group / VP of Developer Ecosystems, NVIDIA)

SECTION 02

THE SIGN THAT THE METAVERSE IS FACING AN EXPLOSIVE GROWTH



There will be a larger market, larger industry with more designers and creators building digital things in virtual worlds than there will be in the physical world. Today, most designers focus on physical world cars, buildings, clothing and shoes. All of those things will be many, many times larger in virtual worlds - this is the next evolution of the web. Just like the web did, virtual worlds will spark many new economies, larger than our current physical economy. The economy in the metaverse will be many times larger than those in the physical world. Digital currencies will be used in these virtual worlds where we own property, homes, cars, art, clothing, and more.

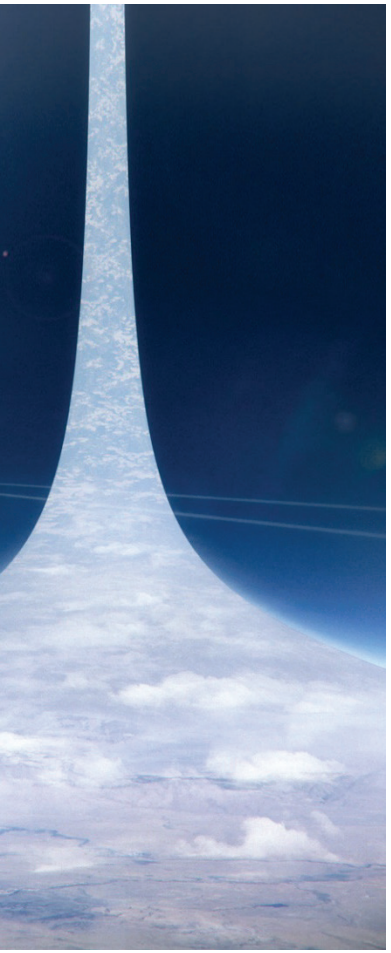
—— **Rev Lebaredian** (VP of Omniverse & Simulation Technology, NVIDIA)

The metaverse is here, but we are very early on the adoption curve when usage is driven by innovators in their respective industries. **Concepts such as simulation and digital twin are gaining traction, but for most limited to the conceptual level.** Increased manufacturing, materials, and labor costs combined with environmental pressures are already accelerating the adoption of highly sustainable technologies such as the metaverse. I expect widespread adoption over the next 5 years.

—— **Danny Lange** (Senior VP of AI, Unity)

SECTION 02

THE SIGN THAT THE METAVERSE IS FACING AN EXPLOSIVE GROWTH



It has not happened yet, because **adults (those over 14 years old, in particular) do not yet use social online spaces.**

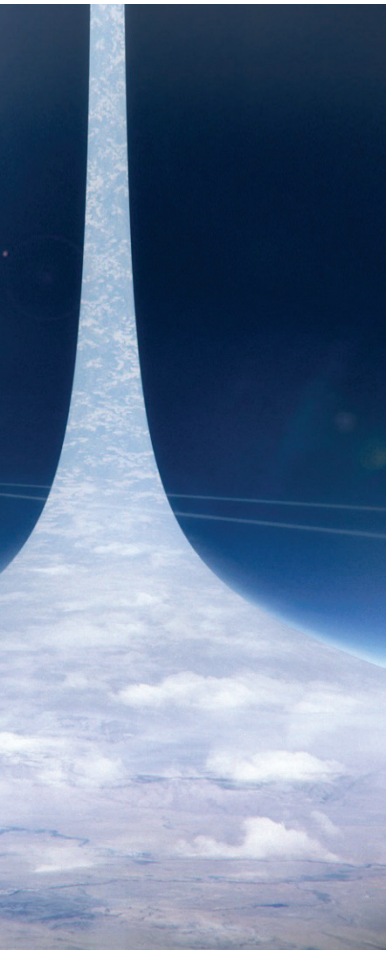
—— **Philip Rosedale** (Founder, Linden Lab / Second Life)

There is a ton of industry interest in the metaverse right now, and I think that's a clear example of the potential and power of it. Our hope is that within the next decade, the metaverse will reach a billion people, host hundreds of billions of dollars of digital commerce, and support jobs for millions of creators and developers.

—— **Caitlin Kalinowski** (Head of AR Hardware, Meta)

SECTION 02

THE SIGN THAT THE METAVERSE IS FACING AN EXPLOSIVE GROWTH



At the moment metaverse is in the path to the 'peak of inflated expectations' phase.

—— **Evelyn R. Miralles** (Former NASA Chief Engineer & VR/AR Pioneer / Board Member, Speaker & Consultant)

Several surveys over the past few years have demonstrated that 70-80% of all businesses have either explored or deployed XR to improve their businesses. And with endless case studies and reports confirming significant business value and ROI from using this tech - **the adoption will only accelerate and FOMO will play a key role in the explosive growth.**

—— **Ori Inbar** (Co-founder & CEO, Augmented World Expo)

The behaviors of pre-teens, especially young girls.

—— **Matthew Ball** (CEO of Epyllion, a Metaverse-focused holding company / Widely acclaimed Metaverse thought leader)

SECTION 03

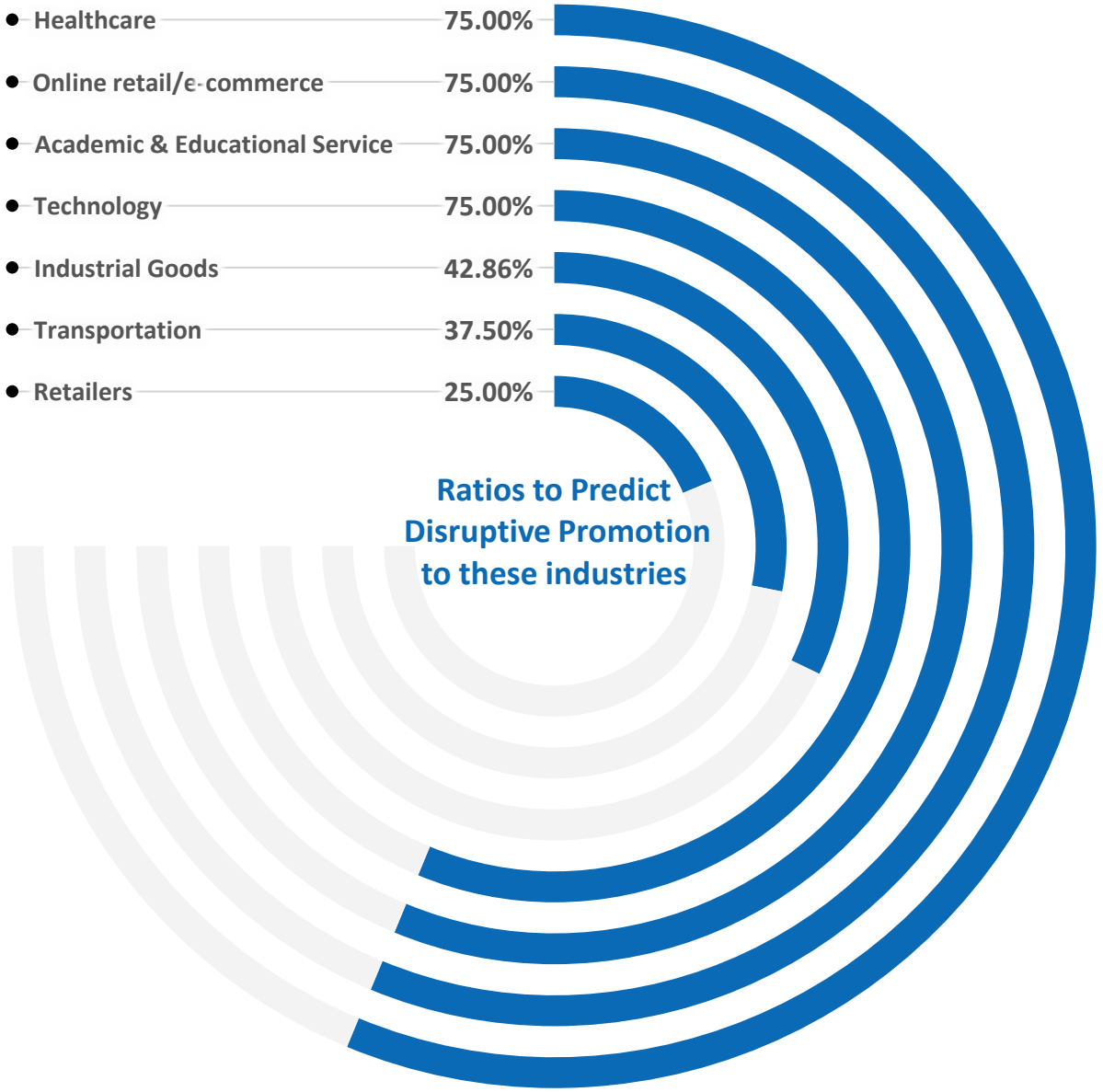
PREDICTIONS

The future of the metaverse predicted by industry and by application scenario

SECTION 03

Predictions

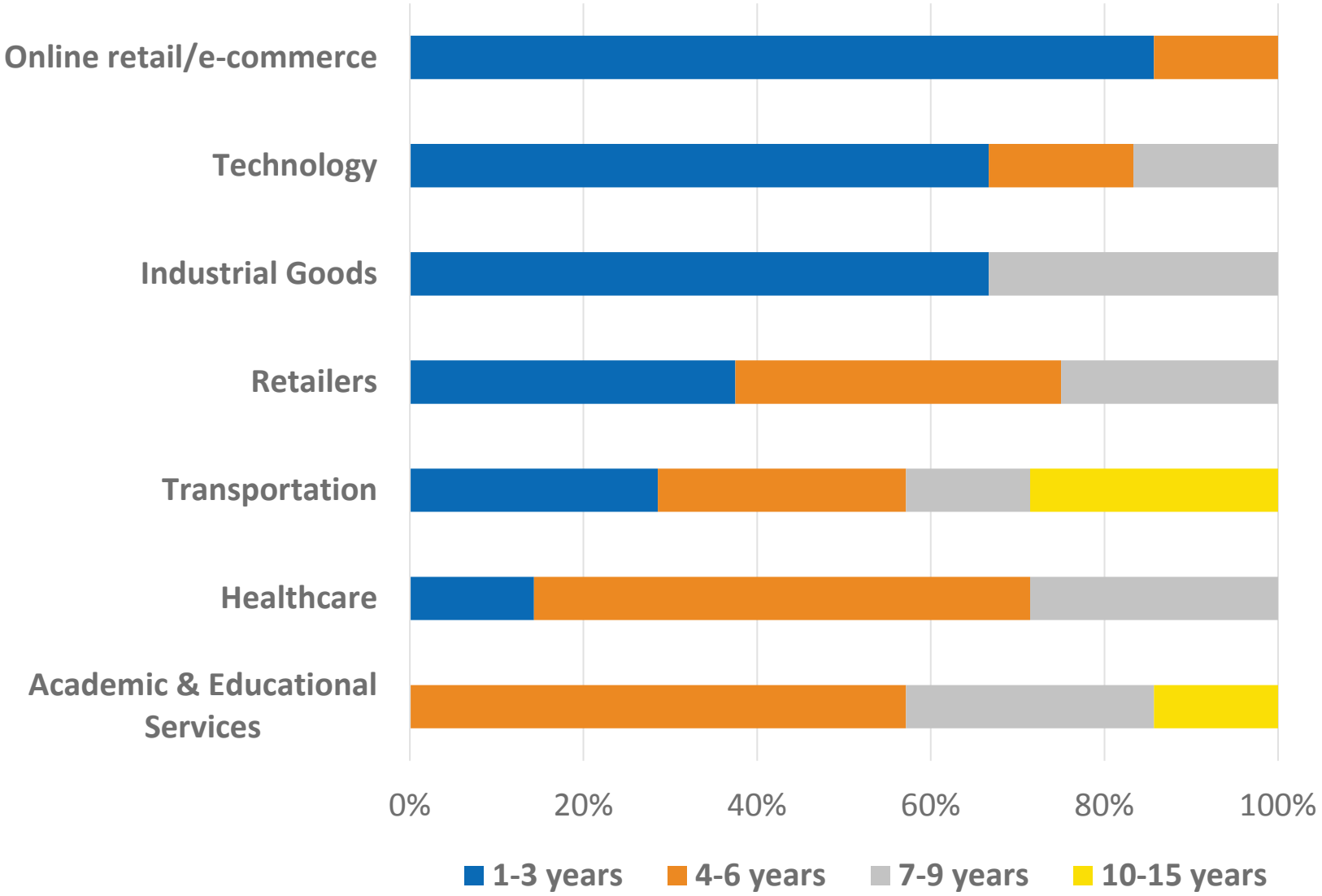
Will the metaverse make a positive or negative impact on the following industries respectively? How significant will the impacts be eventually?



SECTION 03

Predictions

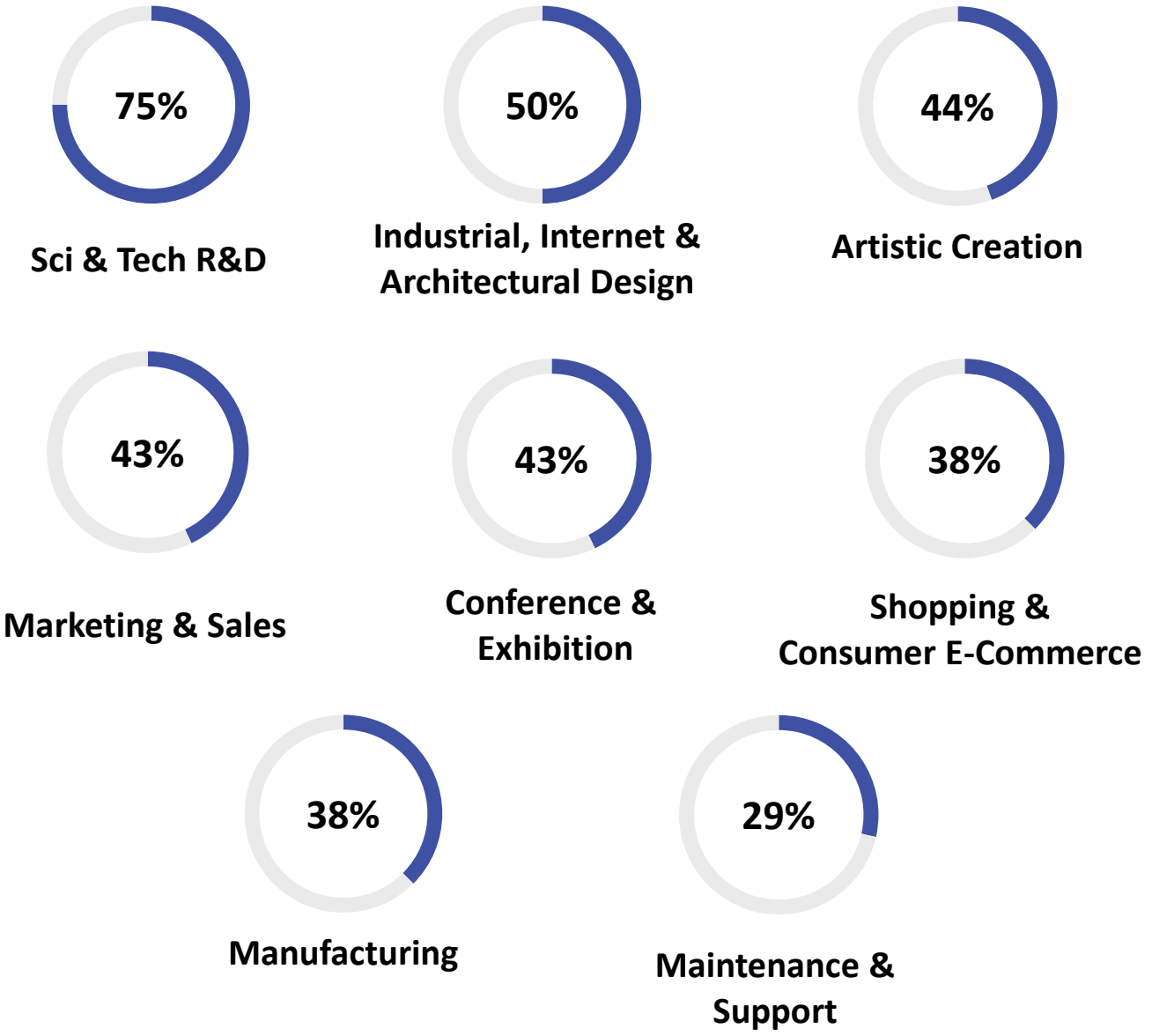
When will the impacts happen ?



SECTION 03

Predictions

The following scenarios of the metaverse are frequently mentioned today.
Please predict the market potential of each scenario.

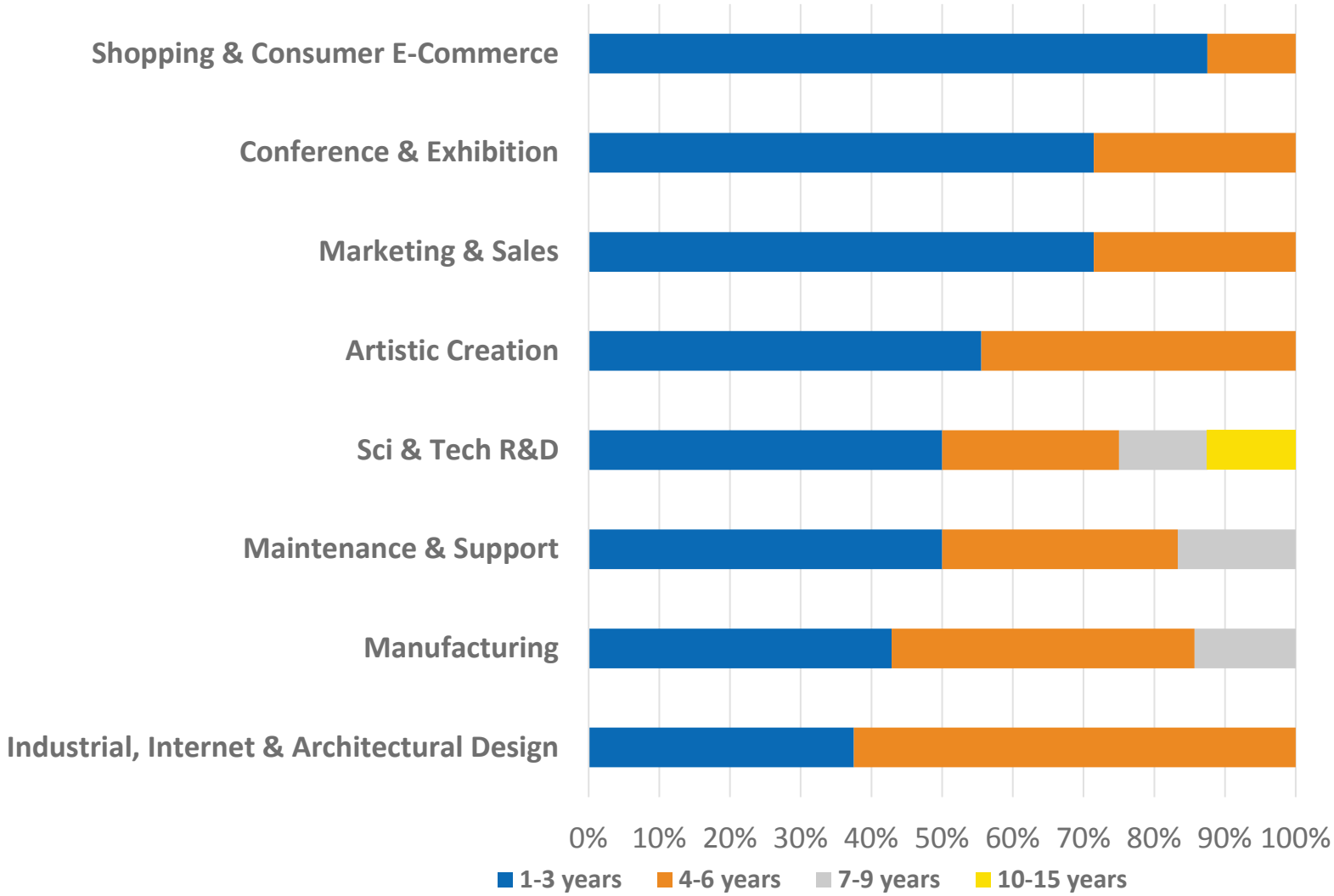


Right: Ratios of predicting big market potential to following scenarios

SECTION 03

Predictions

Please predict the time to market of each scenario.



SECTION 04

WHO WE ARE

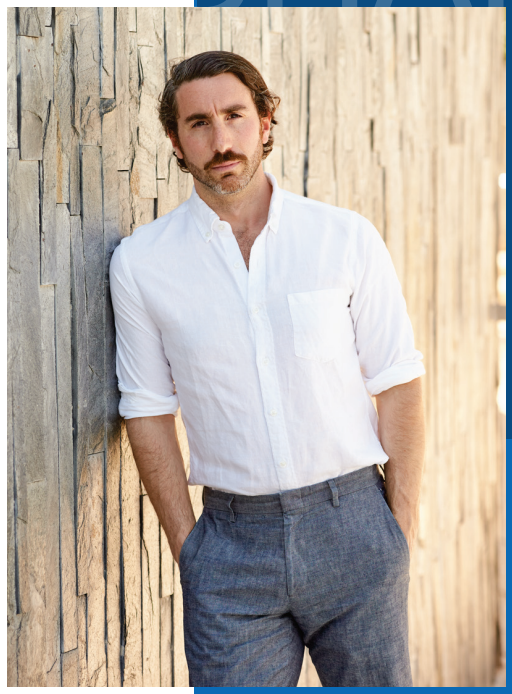
About the Top Experts

MOVERS AND SHAKERS

Matthew Ball

CEO of Epyllion, a Metaverse-focused holding company
Widely acclaimed Metaverse thought leader

Matthew Ball is CEO of EpyllionCo, a Metaverse-focused holding company that operates an early stage venture fund, corporate and venture advisory arm, and content production company. Matthew is also a Venture Partner at Makers Fund, Advisor to KKR, and a co-founder of Ball Metaverse Research Partners, which creates and maintains the index behind the Roundhill Ball Metaverse ETF, which can be found on the New York Stock Exchange (Ticker: $METV). Matthew's forthcoming book, "THE METAVERSE and How It Will Revolutionize Everything" will be published by W. W. Norton in July 2022.



Matthew Ball

MOVERS AND SHAKERS

Thomas A. Furness III

"Grandfather of Virtual Reality"
Professor, University of Washington

Tom Furness is an amalgam of Professor, Inventor, Virtual Reality Pioneer and Entrepreneur in a professional career that spans 55 years. He has made notable contributions in photonics, electro-optics, human interface technology, and is considered the 'grandfather' of virtual reality and augmented reality. Tom earned a BS degree in Electrical Engineering from Duke University and the Ph.D. in Engineering and Applied Science from the University of Southampton, England. He currently a professor of Industrial and Systems Engineering at the University of Washington (UW), Seattle, Washington, USA. He is the founder of the Human Interface Technology Laboratory (HIT Lab) at UW and founder and international director of the HIT Lab NZ at the University of Canterbury, Christchurch, New Zealand and the HIT Lab Australia at the University of Tasmania, Launceston, Tasmania.

Prior to joining the faculty at the UW, Tom served a combined 23 years as an U.S. Air Force officer and civilian scientist at the Armstrong Laboratory at Wright-Patterson Air Force Base, Ohio, where he developed advanced cockpits and virtual interfaces for the Department of Defense. He is the author of the Super Cockpit program and served as the Chief of Visual Display Systems and Super Cockpit Director until he joined the University of Washington in 1989.

Since the beginning of his career Tom has continued to play an active role in virtual and augmented reality development and application. In 1998 he received the Discover Award for his invention of the virtual retinal display. Tom is co-inventor of the ChromaID technology licensed to Visualant Inc. and received the 2013 SPIE Prism Award for this work. In June 2015 he gave keynote titled 'Being the future' at the Augmented World Expo in Santa Clara, California, where he received the first 'Auggie' lifetime achievement award for his 50-year contribution to the VR and AR Industries. In March 2016 Tom received the IEEE VR Career Award for his lifetime contributions to the fields of virtual and Augmented Reality and in October 2016 the Virtual Reality Foundation of Los Angeles Proto Award also for lifetime achievement. Most recently in November 2021 Tom was presented the Accenture Lifetime Achievement Award by the Academy of International Extended Reality and Elected to the IEEE VTCG Academy.

Tom lectures widely and has appeared in many national and international network and syndicated television science and technology documentaries and news programs. He has testified before the U.S. Senate Commerce Committee. He is the inventor of the personal eyewear display, the virtual retinal display, the HALO display and holds 24 patents in advanced sensor, display and interface technologies. With his colleagues and students Dr. Furness has published over 400 papers and conference proceedings and started 27 companies, two of which are traded on NASDAQ at a market capitalization of > $ 12 B (USD). He is a Fellow in the IEEE and a member of the Computer Society and Photonics Society of the IEEE. He is the founder and chairman of the Virtual World Society, a non-profit for extending virtual reality as a learning system for families and other humanitarian applications. He has recently been named an Accenture Luminary.

Dr. Thomas A. Furness III

MOVERS AND SHAKERS

Ori Inbar

Co-founder & CEO, Augmented World Expo (AWE)

Ori Inbar is founder of Super Ventures, the first early-stage fund dedicated to Augmented Reality (AR).

Ori is also the co-founder and CEO of AWE XR, a global community dedicated to advancing augmented reality (AR) and Virtual Reality (VR). Since 2010, over 5000 companies and 50,000 professionals have trusted AWE to connect, learn and grow their business in the XR ecosystem - via conferences, meetups, classes, award competitions, industry news, and thousands of free videos about everything XR.

In 2009, Ori was the co-founder and CEO of Ogmento, one of the first venture-backed companies conceived from the ground up to develop and publish augmented reality games - games that are played in the real world.

Ori has been an enterprising champion of the augmented reality industry since 2007. He established Games Alfresco - a leading augmented reality blog that helped popularize AR, and in 2010 co-founded the Augmented World Expo (Formerly ARE) - the world's largest and most influential conference for AR - now in its 13th year.
Ori is a recognized speaker in the AR industry, lecturer at NYU, as well as a sought after adviser and board member for augmented reality startups.

Previously, as Senior Vice President of Solution Marketing for SAP's platform, Ori was responsible for the positioning and marketing of SAP NetWeaver - which under his leadership grew from a mere concept to a billion dollar business for SAP.
Prior to SAP, Ori joined TopTier Software, as one of the first employees of this start-up.
He lead the development and introduction to the market of more than 15 multimedia and business applications including the world's leading enterprise portal, which in 2001 was acquired by SAP for $400 Million.

Ori Inbar

Caitlin Kalinowski

Head of AR Hardware, Meta

Caitlin Kalinowski leads the AR Hardware team for Reality Labs at Meta. Previously, she led VR Hardware, the division responsible for the Meta Quest 2 and Touch controllers, and the Oculus Rift, Go and Rift S. Before working at Oculus, Caitlin was a technical lead at Apple on the Mac Pro and MacBook Air products and was part of the original unibody MacBook Pro teams. Caitlin received her BS in Mechanical Engineering from Stanford University in 2007.

Caitlin is passionate about increasing the number of women and other underrepresented minorities in the fields of technology and design. She believes the next generation of products must be designed and engineered by people with different backgrounds and experiences to create the best possible product. Caitlin is on the Board of Axon, as well as on the strategic board of Lesbians Who Tech, the largest women's tech conference in California and the largest LGBTQ professional network in the world.

Caitlin Kalinowski

Danny Lange

Senior VP of AI, Unity

Danny Lange is Senior Vice President of Artificial Intelligence at Unity Technologies where he leads efforts to advance the capabilities of AI through scalable 3D simulations. Prior to his role at Unity, Danny was the head of Machine Learning at Uber where he led the development of the company's Machine Learning platform. Previously, he was General Manager for Machine Learning at Amazon where he managed Amazon's internal Machine Learning platform as well as launched the first AI product for Amazon Web Services (AWS) known as Amazon Machine Learning. Danny has also led Machine Learning efforts at Microsoft and started his career building autonomous agents as a Computer Scientist at IBM Research.

Danny Lange

MOVERS AND SHAKERS

Rev Lebaredian

VP of Omniverse & Simulation Technology, NVIDIA

Rev Lebaredian is vice president of Omniverse and simulation technology at NVIDIA. From the dawn of the computer graphics revolution to the present day, Rev Lebaredian has always been at its cutting edge. His career has seen him plying his skills at Warner Brothers Digital and Disney Dream Quest Images before starting his own venture, Steamboat Software. Top VFX studios around the world have used his work in rendering and volumetric algorithms in many popular films such as “Stuart Little,” “Dr. Seuss’ How the Grinch Stole Christmas,” “X-men 2”, and many more. After moving to NVIDIA, Rev began work on the first shading language for programable GPUs and since then has helped NVIDIA’s teams take on numerous disparate challenges, including large scale automated testing of 3D apps (GTL), advancing real-time physics simulation (PhysX), in-game photography (Ansel), robotics simulation (Isaac Sim), and immersive product design and visualization (Project Holodeck). While his past achievements are numerous, it’s the future he finds the most exciting. For the last five years, he and his teams have been combining the rendering, physics simulation, and artificial intelligence technologies pioneered by NVIDIA into a single platform for creating and simulating physically-accurate virtual worlds—NVIDIA Omniverse. Rev continues to lead the Omniverse product, engineering, and research teams as Vice President of Omniverse and Simulation Technology.

Rev Lebaredian

MOVERS AND SHAKERS

Steve Mann

"Father of Wearable Computing"
Professor, University of Toronto

Steve Mann was born in Ontario, Canada where, in his childhood in 1975, he invented the SWIM (Sequential Wave Imprinting Machine), for extended reality wave computations that allows users to interact with the computations, and with each other, to see wave propagation in air, underwater, and in solid materials. SWIM was the first example in the new field of Water-Human-Computer Interaction (WaterHCI).He also invented the chirplet transform for interactive marine radar, that works with SWIM, and published this work in 1992.
In 1999 Mann founded the WaterHCI DECONference series (waterhci.com) and will be doing the 26th annual WaterHCI-2023 conference through IEEE VR.

Mann is Full Professor, University of Toronto, Chair of the Silicon Valley Innovation & Entrepreneurship Forum (SVIEF), Founding Member of the IEEE Council on Extended Intelligence, Invented wearable computing in his childhood, brought this invention to MIT to found the MIT wearable computing project, and "persisted in his vision and ended up founding a new discipline." -- Nicholas Negroponte, MIT Media Lab Director, 1998.
Invented, designed, and built the world's first smartwatch in 1999 (patent filed 2000, featured on cover of Linux Journal July 2000) which he presented at IEEE ISSCC 2001 where he was named "The father of the wearable computer".

Inventor of HDR (High Dynamic Range) imaging, used in more than 3 billion smartphones. ("The first report of digitally combining multiple pictures of the same scene to improve dynamic range appears to be Mann 1993" -- Robertson etal, JEI 12(2).)
Inventor of the hydraulophone, world's first water-based musical instrument. It is also a new kind of physiotherapy device, as well as a new way of sensing water quality by sensing sound propagation in water.

Steve Mann

Evelyn R. Miralles

Former NASA Chief Engineer & VR/AR Pioneer
Board Member, Speaker & Consultant

Evelyn Miralles is an executive leader and a pioneer in computer technologies with over 30 years of extensive experience in roles within the public and private sectors. She has a successful record of creating partnerships and generating initiatives that lead to innovative solutions, benefiting our growing diverse and digitally connected world.

During her 27 years tenure at NASA's Johnson Space Center, Miralles served as the Chief Principal Engineer within the Engineering Division leading a highly-technical, visible and critical astronaut training facility, supporting R&D for operations in space. Her computer acumen and vision helped to advance 'Human Space Exploration' by developing state-of-the-art flight software and hardware systems, with the purpose to prepare astronauts to perform dangerous excursions in micro-gravity. She led in the development of innovative immersive graphical applications that successfully supported every Space Shuttle and International Space Station mission since 2000, as well as helping to establish the Commercial Crew Program in 2011. Miralles co-wrote the state-of-the-art flight software 'Dynamic Onboard Ubiquitous Graphics' (DOUG), the first virtual reality ready training tool used to prepare astronauts for spaceflight. She currently serves as a Business Associate for Aegis Aerospace Inc., providing support to the executive team in matters of space related business strategies and contracting

Currently Miralles serves as a Business Associate for Aegis Aerospace Inc, a defense and space manufacturing company, providing her expertise building internal teams, competitive products and services, considering new market trends and requirements, including technology foresight. She retired in May 2022 from her administrative leadership role in higher education as the Associate Vice President for Strategic Information Initiatives and Technology at the University of Houston Clear Lake (UHCL), where she was an executive and advisor for the University's President's office. Miralles provided guidance in matters of policy and development of procedures, monitoring and overseeing their implementation and enrollment impacts via her participation in share governance committees such as the University Council, Planning and Budgeting, and Facilities and Support Services. She also served as a lecturer for the college of Computer Science and Engineering, providing presentations in technologies and business strategic planning. In her position, Miralles successfully founded of a new Institute for Human and Planetary Sustainability (IHAPS), aiming to promote innovative solutions and sustainable outcomes to global challenges through a multi-disciplinary approach and applied research, bringing social, economic, environmental, and educational perspectives to the forefront. She is currently serving as a member of the Great Houston Partnership (GHP) organization (Aerospace and Aviation Committee), the Bay Area Houston Economic Partnership (BAHEP), the Hispanic Association of Colleges and Universities (HACU), and the American Association of States Colleges and Universities (AASCU).

Miralles has been honored with the prestigious 'Flight Safety Award' presented by the elite NASA's Astronaut Crew Office. She also received the University of Houston Clear Lake 'Distinguished Alumna' in 2016, amongst other national and international recognitions. She was named as one of BBC's 'Top 100 Inspirational Women in the World' in 2016, one of CNET's 'Top 20 Most Influential Hispanics in Technology' for 2015 and 2016. She lends her experience and knowledge to the field of computer engineering and mix realities technologies, as well as her passion and experience in executive leadership and strategic planning on a national and international level, commercially and within government agencies and universities. Among her proudest roles, however, is to encourage young students and professionals to pursue and succeed in the fields of Science, Technology, Engineering and Math (STEM) education through lectures and other outreach efforts. Miralles holds a Bachelor of Science in Computer Graphics (CS) from Lamar University, a Bachelor's in Computer Information Systems (CIS) and a Master's in Business Administration (MBA) from the University of Houston Clear Lake.

Evelyn R. Miralles

MOVERS AND SHAKERS

Philip Rosedale

Founder, Linden Lab / Second Life

Philip Rosedale is the Founder of Linden Lab, parent company of Second Life, an open-ended, Internet-connected virtual world and pioneering metaverse. Following Second Life, he worked on several projects related to distributed work and computing. Excited by innovations in these areas and the proliferation of new VR-enabling devices, he re-entered the virtual worlds space in 2013, co-founding High Fidelity, a company devoted to exploring the future of next-generation shared virtual reality. Philip rejoined Second Life in 2022, as Strategic Advisor, focused on helping to shape and build a better metaverse.

Prior to Linden Lab, Philip created an innovative Internet video conferencing product ("FreeVue"), which was later acquired by RealNetworks, where he went on to become Vice President and CTO.

Philip Rosedale

MOVERS AND SHAKERS

Neil Trevett

President, Khronos Group
VP of Developer Ecosystems, NVIDIA

At NVIDIA, Neil helps developers make best use of GPUs, has he has been involved in the creation open standards for many years. The metaverse has been a long-term inspiration, even if he didn't realize it at the time. He has helped OpenGL onto PCs, served as President of the Web3D Consortium, and as Khronos President has been involved in the creation of multiple widely adopted standards for 3D and XR including OpenGL ES, WebGL, Vulkan, glTF and OpenXR.

Neil Trevett

MOVERS AND SHAKERS

Yu Yuan

President-Elect, IEEE Standards Association
Co-founder, VerseMaker

Dr. Yu Yuan, IEEE Board Director-Elect and IEEE Standards Association President-Elect, is a visionary researcher, inventor, practitioner, and entrepreneur in the areas of Consumer Technology, Multimedia/VR/AR, Connected/Automated Vehicles, IoT, and Digital Transformation. He co-founded VerseMaker, a metaverse enabling platform facilitating global collaboration and innovation on the metaverse by information exchange, expert network, and investment. He founded 0xSenses Corporation (also known as Senses Global Corporation or Senses Global Labs & Ventures in different countries), a multinational technology company specializing in Virtual Reality, Augmented Reality, and Human Augmentation. Dedicated to "Creating Better Worlds" as its long-term vision, the company is developing technologies, infrastructures, ecosystems, and resources needed for massively multiplayer ultra-realistic virtual experiences. Prior to this he worked for IBM Research as a research scientist and was a key contributor to IBM's Cell Broadband Engine, Smarter Planet, and IoT initiative. He has been a passionate volunteer in various leadership positions at IEEE and other professional organizations. He is also serving as Chair of IEEE Consumer Technology Society Emerging Technology Standards Committee (CTS/ETSC), Chair of IEEE Virtual Reality and Augmented Reality Standards Committee (CTS/VRARSC), Vice Chair of IEEE Photonics Society Standards Committee (PHO/SC), Secretary of IEEE Consumer Technology Society Blockchain Standards Committee (CTS/BSC), Chair of IEEE VR/AR Advisory Board, Member-at-Large of IEEE Consumer Technology Society Board of Governors, Corresponding Member of IEEE Technical Activities Board Committee on Standards, and Member of IEEE Strategy and Alignment Committee. He has a Ph.D., an M.S., and a B.S. in Computer Science from Tsinghua University.

Yu Yuan

VERSEMAKER

About VerseMaker

VerseMaker is a metaverse enabling platform facilitating global collaboration and innovation on the metaverse by information exchange, expert network, and investment. It is committed to becoming a bridge and catalyst for China's research and development, education and training, large enterprises, start-up companies, and investment institutions to participate in the global metaverse innovation and cooperation ecosystem.

Editorial Board

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