



EXECUTIVE DIGEST

Go boldly! Explore augmented reality (AR), virtual reality (VR), and mixed reality (MR) for business



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KEYWORDS

Augmented reality;
Virtual reality;
New technologies;
Real constructs;
Possible constructs;
Information shadow

Abstract It is not surprising that managers find it hard to distinguish similar-sounding, IT-based concepts such as augmented reality and virtual reality. To many, all of these constructs mean nearly the same and, as a result, the terms are often used interchangeably. This confusion holds back those eager to explore the different opportunities these new technologies present. This Executive Digest presents six different types of reality and virtual reality—(1) reality, (2) augmented reality, (3) virtual reality, (4) mixed reality, (5) augmented virtuality, and (6) virtuality—as part of our actual reality/virtual reality continuum. We then illustrate their differences using a common example and outline business applications for each type.

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1. Yesterday's imagination, today's reality

Many of today's technologies were first conceived of in science fiction, born from the ideas of futurologists who let their imaginations run wild and pictured what

tomorrow might look like. *Star Trek* alone has strongly influenced many such real-world inventions: 3-D printers take after the *Star Trek* replicator, iPad/tablet computers bear an uncanny resemblance to Jean-Luc Picard's personal access display devices (PADD), and virtual assistants like Siri and Alexa remind us of the way commanders talked to their ship's library (aka the Federation of Planets' library computer access/retrieval system).

Most interesting today is how *Star Trek's* holodeck was a precursor to many recent technological developments. One of the most

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mind-bending plot devices used in the series, it allowed anyone entering the holodeck to engage with holographic images that appeared solid to the touch, to travel to different locations, and even to be introduced to events and persons from different galaxies or from the past. Since its first appearance in 1974, the holodeck's ability to interact with simulated environments has inspired the work of generations of researchers in computer science, artificial intelligence, computer graphics, and human-computer interaction (Zambetta, 2017). What they have in common is a fascination with the prospect of living in one reality and experiencing another. Their advancements, especially in the last few years, have progressed us to a very confusing world today, one in which various different, alternative versions of reality coexist. It is not surprising that managers find it hard to distinguish similar-sounding, IT-based concepts such as augmented reality, virtual reality, virtuality, and mixed realities. In fact, to many managers, all of these constructs mean nearly the same and, as a result, the terms often are used interchangeably. This confusion holds back those eager to explore the different opportunities these new technologies present.

2. The actual reality/virtual reality continua

To understand our world in terms of various, alternative forms of reality, we turn to French philosopher Gilles Deleuze. Half a century ago, before discussions

around augmented and virtual environments would become massively popular, Deleuze (1966) described how our world consists of real and of possible constructs. *Real constructs* are either actual (e.g., physical objects we can touch, like a laptop) or virtual (e.g., virtual assistants like Siri or Alexa that are nowhere in actuality, but are nonetheless real and can be interacted with). *Possible constructs*, on the other hand, are exactly like the real except for the contingency that they do not, in fact, yet exist (Shaviro, 2007).

This separation matters a lot, as we currently tend to incorrectly overgeneralize reality as referring to real, physical existences and to augmented and virtual realities as digital variations thereof. Not only is such a view too crude, Deleuze reminds us that virtual is not opposed to real but it is opposed to actual, whereas real is opposed to possible (Deleuze, 1966). Now that we have confused you even more with these terms, we proceed by explaining the different types of reality through an actual reality/virtual reality continuum (Figure 1). We then illustrate their differences through the common example of real estate transactions and outline business applications for each type.

3. Actual reality continuum

The actual reality continuum deals with elements that exist or experiences that take place in the actual, material world around us—either in a pure sense, without the help of any type of IT, or with additional

Figure 1. The actual reality/virtual reality continuum

Reality	Augmented Reality	Virtual Reality	Mixed Reality	Augmented Virtuality	Virtuality
The actual world that we experience with all of our senses.	Information and data overlaid on top of the actual world.	A complete digital representation of the actual world.	The introduction of possible elements into an actual world.	The introduction of actual elements into a possible world.	An imaginary world that mostly follows the rules of the actual world.
An actual house.	A realty app provides details of an actual house.	A 3D image of actual furniture. A virtual tour of an actual house.	Simulation of different furniture, virtual or new, in an actual house.	Staging of actual furniture in a new house.	A 3D model for a new house or of new furniture.
Key concept: Physical co-presence of people and objects.	Key concept: Add utility to physical co-presence.	Key concept: Enable perceived presence and full immersion.	Key concept: Adaptation of actual scenarios.	Key concept: Participation in possible scenarios.	Key concept: Vision of a completely different world.
Real			Possible		
Actual Reality Continuum			Virtual Reality Continuum		

data about the actual world provided to us through IT. This continuum includes reality in its authentic and genuine sense as well as augmented reality.

3.1. Reality

The concept of reality is not as clear-cut as one might imagine and although philosophers like Aristotle, Plato, Wilson, or Dummett have long pondered and theorized its definition and boundaries, we will not discuss the different epistemological views here. Simply put, reality refers to the actual, physical world that exists and that we navigate every day—the people and objects around us that we experience with all of our senses. This reality is what originally gave rise to all business activity and, despite the advancements of information and communication technologies, the majority of commercial transactions (e.g., in retail, manufacturing, services) still happen in the physical co-presence of people and objects. In real estate transactions, for instance, a potential buyer commonly meets the seller's agent in person to view the actual house of interest.

3.2. Augmented reality

Augmented reality (AR) refers to the integration of the actual world with digital information about it. Actual objects and people cast an *information shadow*: an aura of data which, when captured and processed intelligently, can offer extraordinary value to consumers (O'Reilly & Battelle, 2009). Augmented reality uses technology to make such a layer of information accessible to people—to blend one's perception of the actual world with digital content about it generated by computer software. This technology comes in a myriad of forms: from wearables and smart glasses that use retinal projection to put a display in the wearer's eyeball (e.g., Google Glass was a very noticeable AR headset, the Vaunt by Intel is much less conspicuous) to the more commonly used smartphones. The AR layers that are added can be sensory (e.g., sound, video, graphics, or haptics) or simply data based. To follow the real estate example above, Realtor.com is developing an AR application that allows house hunters to explore a neighborhood in creative new ways. When a phone's camera points at a home, even if it is not for sale, the app instantly displays information about it, including the last sale prices, taxes, and lot size. This allows the user to judge whether an actual listing is a fair market price.

Rather than just providing the user with data that was collected previously, AR can also let the user generate data about the actual world. The AR app Measured by Lowe's lets users determine and share the dimensions of actual objects with their

smartphone cameras instead of a tape measure. What's important to remember is that with AR, the user is very much aware that they find themselves in the actual, physical world.

In terms of business opportunities, AR applications can be used to change how today's always-connected consumers work and shop. By providing additional information about actual offerings, AR can enhance a customer's real-world experience in interesting ways. For instance, using an app called 19 Crimes, consumers can point their smartphone at a bottle of 19 Crimes wine and watch the convicts depicted on the actual wine labels come to life (Cawley, 2017). With AR-enabled smart glasses or phones, shoppers could easily walk down an aisle and identify groceries on shelves that fit their dietary restrictions (e.g., those that are gluten-free, non-GMO, nut-free). Similarly, AR could lead a shopper through the store to find items on a shopping list, make recommendations for complementary products, and keep a running total of items in the cart. Using GPS mobile apps with AR allows businesses in tourism to show visitors routes and directions to desirable destinations and to provide additional information for cultural events or historical sites. Another way of adding data on top of the actual world includes using AR applications such as Google Translate for real-time voice and text translation in customer service encounters or in international meetings (Russell, 2015).

4. Virtual reality continuum

In contrast to the actual reality continuum, we have chosen the term *virtual reality continuum* to reflect all the different types of realities that people commonly associate with virtual reality. As we show below, virtual reality is actually just one type of reality—the beginning of the virtual reality continuum—which also includes mixed reality, augmented virtuality, and virtuality. Each type of reality on the virtual reality continuum is completely virtual; none include any actual, physical items at all, just various combinations of digital versions of what already exists in actuality and what is possible.

4.1. Virtual reality

Virtual reality (VR) refers to complete, 3-D virtual representations of the actual world or of objects within it. For instance, AutoCAD software allows architects, engineers, and design professionals to create precise 3-D drawings of actual buildings before they make changes to them. Virtual 360-degree tours invite others to visit faraway sites. An example of this is the website of the Metropolitan Museum of Art (the

Met) in New York, which invites visitors to a virtual tour of the works of van Gogh and di Bondone. The most impressive virtual realities, though, are scenarios that require VR headsets that look like giant matte black ski goggles. When users wear an Oculus Rift or Samsung Gear VR, they become completely immersed in 3-D computer-generated worlds. Fully realistic images, sounds, and other sensations simulate a user's physical presence of environments that actually exist. Some prominent examples of VR include:

- Google Art and Culture recently launched VR tours of more than 1,200 museums and exhibitions of art;
- President Obama and his wife, Michelle, offer their expertise as VR tour guides of the White House; and
- People for the Ethical Treatment of Animals (PETA) created a VR movie called *I, Chicken* so that viewers can experience the actual conditions of mass animal husbandry.

The same, of course, is true in our real-estate example. Sellers or agents who record a VR video of the premises allow potential buyers to virtually walk around the house and get a realistic impression of the building and yard without ever visiting the site in person. Well-designed VR simulations will even provide different perspectives for viewers of different heights, much like shorter and taller people experience the actual world differently. More impressive even is the fact that, in VR, users can interact with virtual environments; they can walk around a house and open doors and close the curtains and turn the lights on and off to simulate different scenarios.

There are plenty of business applications for virtual reality. Education and training is just one field in which VR seems to offer nearly unlimited business opportunities. Unlike an actual world training scenario, an employee can play through a VR simulation as many times as required to grasp a concept, task, or procedure—regardless of whether it is sales or public speaking (e.g., oculus virtual speech), medical surgery, or operating heavy-duty equipment. In education, for example, virtual reality technology makes learning more engaging by allowing students to interact with virtual models in subjects such as medicine, cosmology, physics, geography, and biology, to name a few. History students can tour an exact virtual replica of the Roman Colosseum, experiencing the monument firsthand without having to travel significant distances (Petch, 2016). Thanks to VR, businesses can reach out to their customers via immersive and engaging marketing campaigns. This is particularly important

in the era of online shopping, as VR experiences help customers explore 3-D renderings of a firm's offering without having to leave their homes.

Virtual reality is different from reality and augmented reality in a very important way, which also sets the foundation for all remaining types of realities on the virtual reality continuum. Unlike a traditional computer, mobile phone, smart spectacles, or a TV set in which users can look to the left and to right and realize that they are still in the actual world (e.g., their living rooms), virtual reality surrounds users as if they were looking or moving in a reality that is different from their actual reality. One can remain in the living room and virtually experience what it's like to go skydiving, visit famous places, or fly through the Arctic. The difference is that VR can be fully immersive. Users often forget where they actually are and even experience a phenomenon called *VR sickness*: the purely visually induced perception of self-motion (rather than actual motion) that leads to symptoms like disorientation, discomfort, headache, and nausea. Such actual symptoms—resulting from perceived presence—show how powerful VR can be and how important it is that care is taken not to misuse its powers.

4.2. Mixed reality

Most discussions of new realities only focus on AR or VR, not paying attention to what is likely the most interesting type of virtual reality for most organizations. Mixed reality (MR) refers to the merging of real world virtual constructs with computer-generated constructs that are either real or possible. Not only does mixed reality (also known as hybrid reality) combine aspects of the actual reality—the physical world around us—with the power of virtual reality, it also combines what's real with what's possible. In other words, mixed realities allow us to experience new objects or scenarios—those that don't actually exist. Imagine adding virtual objects or characters into a live video stream of the real world. In healthcare, for example, medical mannequins are brought to life for training scenarios and teach empathy to healthcare professionals (DeSouza, n.d.). As a manager, do you want to engage employees differently in organizational tasks or increase customer loyalty? Pokémon Go showed us not only how gamification can change behavior, but also how a seamlessly mixed reality can blend the actual with the imaginary world. For our real estate example, potential buyers might want to adapt the actual properties of the houses to imagine what the property could look like. They might be interested in what the walls would look like in a different color, or play with its interior

design by placing a few pieces of furniture from Sweden throughout the property (Demondern, 2018).

With respect to business applications, prototyping and design are areas in which firms are already realizing the benefits of MR. Manufacturers such as automobile giant Ford are using mixed reality applications to add new features to existing vehicles before physical production of a prototype, thus allowing managers to assess and change a new concept more quickly and cost-effectively (Spears, 2017). Furthermore, other teams across the globe can see the live feed of the MR-enabled modifications to the vehicles and provide instant feedback. While altering or adding elements to an actual environment are the most common uses of MR technologies today, there is another promising application: using MR technologies to remove elements from the perceived reality, otherwise known as diminished reality (DR). Organizations may use DR to help with urban planning—remove undesirable items (e.g., noise, traffic, light, garbage) and envision the new design without actually changing anything (Saenz, 2010). Retailers can employ DR to support marketing and sales. For instance, shoppers can use DR applications to visually remove unwanted furniture in an existing room and see how a new sectional might look without the noise of their old furnishings (Besecker, 2017).

4.3. Augmented virtuality

Mixed realities combine what is real and possible with what is actual and virtual. The underlying suggestion was that we add possible items (i.e., objects, people) to actual world scenarios. The difference between MR and augmented virtuality might be small, but it is nonetheless important. In contrast to MR, augmented virtuality (AV) refers to computer-generated possible world scenarios augmented with real, virtual constructs (i.e., objects, people). We might create a fictitious world and add actual people or objects into it, much like flight simulators that construct training scenarios that include fictitious elements but also planes of other pilots who train at the same time.

Businesses can use augmented virtuality to enhance the customer experience by not only manipulating the visual experience, but also stimulating other sensory systems such as smell, taste, or audio. In addition, augmented virtuality offers opportunities in the manufacturing field, particularly for maintenance. With AV, an aircraft maintenance engineer can visualize a real-time model of an aircraft in flight, and monitor and assess the performance of various parts and components. In communications, AV applications enable immersive

experiences that enhance collaboration among geographically dispersed teams. For instance, Skype for Microsoft's HoloLens lets employees put on headsets and start collaborating in virtual worlds with colleagues who are also using Skype without being blocked off from the real world (Quora, 2018).

4.4. Virtuality

As the polar opposite of what is actual and real, virtuality refers to a virtual representation of a possible world. This could include non-actual scenarios that are either realistically possible (e.g., a computer-generated walkthrough of a house at the design stage) or completely (science) fictional (e.g., riding a made-up VR rollercoaster).

Among all types of reality on the virtual reality continuum, virtuality is the most futuristic type. As an illustration of virtuality, the United Arab Emirates (UAE) released a virtual tour of the first settlement on Mars and announced plans to establish this colony by 2117 (Geib, 2017). Visitors are welcomed to the City of Wisdom by a holographic delegate and can immerse themselves in exploring buildings, green spaces, and other objects in this imaginary world.

5. From reality to virtuality—And back!

As we start to explore new and emerging realities and their implications for business, we have to keep two fundamental differences in mind.

- First, following Deleuze, we separate what is real from what is possible and what is actual from what is virtual. Real constructs (e.g., people, objects) are either actual and physical in their nature, or virtual and digital. Both types are real and can be interacted with. In comparison, possible constructs are the results of our imagination that do not yet exist in actuality.
- Second, we have to keep in mind that this separation of real and possible and actual and virtual should not be confused. Virtual and real are not opposites, and neither are actual and possible. On the contrary, when combined properly, we arrive at a number of realities that either belong to the actual reality continuum—where users are keenly aware that they find themselves in the concrete and tangible world—or in the virtual reality continuum, where users can find themselves immersed, forgetting where in the actual world they really are and behaving as if they were

looking or moving in a real reality that is different from their actual reality.

As we have shown, each of the resulting six realities relies on different key concepts. In the actual reality continuum, reality leverages physical co-presence and augmented reality (AR) adds an informational layer on top of this actual world. In the virtual reality continuum, virtual reality (VR) enables perceived co-presence and full immersion, mixed reality (MR) lets users adapt actual scenarios with possible ones, augmented virtuality (AV) invites actual people and objects into possible scenarios, and virtuality refers to visions of a completely different world that might or might not become real in actuality.

This last point is important: The types of realities on the virtual reality continuum that deal with possibilities have significant generative potentiality. In other words, what happens in mixed reality, augmented virtuality, and virtuality has a chance/possibility to happen or exist in the actual, real world in the future. If we simply revisit the real estate example, it is not hard to see how a 3-D model of a new house can lead to building the actual house, or how virtually staging new furniture in one's house can lead to actual changes to room furnishings. The same potentiality that becomes fulfilled in the actual can drive all sorts of business applications, including new product development, maintenance, education, training, customer service, and many more areas that are currently dominated—and limited—by the actuality of the real world.

6. Beyond the holodeck

In many of the futuristic predictions of technology, *Star Trek* has led the way. When the holodeck was introduced to the series, it was perceived as too fantastic to exist in the real world. Only about 40 years later, the global sale of reality-enhancing hardware is expected to grow to \$17.8 billion in 2018 and the industry is expected to be worth \$215 billion by 2021 (Mainelli, 2017). While most of today's applications of different realities seem to be for entertainment purposes, their use in the business world is growing fast. Gartner expects that virtual reality alone, for example, is already on the "slope of enlightenment" on the Gartner Hype Cycle (Panetta, 2017)—a forecasting tool that is also being used in academia (Kietzmann, Pitt, & Berthon, 2015)—and it is only 2 to 5 years away from the "plateau of productivity," when mainstream adoption among firms will start to take off.

The main purpose of this short commentary was to prepare managers for the exciting growth and

potential of reality-enhancing applications. We highlighted how the six types of reality vary, and we hope that many managers will "Go boldly!" and explore how each type of reality can contribute to business applications in different, value-creating ways. A more general purpose of this commentary was to alert managers to the constantly changing opportunities that emerging technologies present. And of course, we wanted to talk about how influential the *Star Trek* series has been, and will continue to be, in envisioning and building our future. In that sense, we urge managers and researchers to consider how other forms of reality can drive business applications today, and we hope they will join us in looking for new opportunities on the horizon. "Let's see what's out there."

References

- Besecker, B. (2017, October 26). Diminished reality will have as much power as AR for retailers. *VentureBeat*. Available at <https://venturebeat.com/2017/10/26/diminished-reality-will-have-as-much-power-as-ar-for-retailers/>
- Cawley, C. (2017, November 2). This augmented reality app will bring your wine bottle to life. *TechCo*. Available at <https://tech.co/augmented-reality-app-wine-2017-11>
- Deleuze, G. (1966). *Le bergsonisme*. Paris, France: PUF.
- Demodern. (2018). *IKEA virtual reality showroom*. Available at <http://demodern.com/projects/ikea-vr-showroom>
- DeSouza, C. (n.d.). Mixed reality — AR, VR, and holograms for the medical industry. *Real Vision*. Available at <http://realvision.ae/blog/2016/04/mixed-reality-ar-vr-holograms-medical/>
- Geib, C. (2017, November 29). The UAE released a VR tour of the first city on Mars. *Futurism*. Available at <https://futurism.com/uae-released-vr-tour-first-city-mars/>
- Kietzmann, J. H., Pitt, L. F., & Berthon, P. (2015). Disruptions, decisions, and destinations: Enter the age of 3-D printing and additive manufacturing. *Business Horizons*, 58(2), 209–215.
- Mainelli, T. (2017). Worldwide augmented and virtual reality hardware forecast update, 2017–2021: CY 4Q17. *IDC*. Available at <https://www.idc.com/getdoc.jsp?containerId=US41466317>
- O'Reilly, T., & Battelle, J. (2009). *Web squared: Web 2.0 five years on*. Available at http://assets.en.oreilly.com/1/event/28/web2009_websquared-whitepaper.pdf
- Panetta, K. (2017, August 15). Top trends in the Gartner Hype Cycle for emerging technologies, 2017. *Gartner Inc*. Available at <https://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017/>
- Petch, N. (2016, April 25). Virtual reality offers plenty of business opportunities for entrepreneurs. *Entrepreneur*. Available at <https://www.entrepreneur.com/article/274586>
- Quora. (2018, February 2). The difference between virtual reality, augmented reality, and mixed reality. *Forbes*. Available at <https://www.forbes.com/sites/quora/2018/02/02/the-difference-between-virtual-reality-augmented-reality-and-mixed-reality/#67c952d02d07>
- Russell, J. (2015, January 14). Google Translate now does real-time voice and sign translations on mobile. *TechCrunch*. Available at <https://techcrunch.com/2015/01/14/amaaaaaazing/>

- Saenz, A. (2010, November 5). New augmented reality software removes objects from video feeds in realtime. *SingularityHub*. Available at <https://singularityhub.com/2010/11/05/new-augmented-reality-software->removes-objects-from-video-feeds-in-realtime/#sm.000000l26y8wuvdp3s141kaxt1mf0>
- Shaviro, S. (2007, May 9). *Kant, Deleuze, and the virtual*. Available at <http://www.shaviro.com/Blog/?p=577>
- Spears, T. (2017, January 15). Ford's virtual reality lab revolutionizes vehicle design process. *DesignBoom*. Available at <https://www.designboom.com/technology/ford-virtual-reality-lab-vehicle-design-01-15-2017/>
- Zambetta, F. (2017, March 28). Star Trek's holodeck: From science fiction to a new reality. *The Conversation*. Available at <http://theconversation.com/star-treks-holodeck-from-science-fiction-to-a-new-reality-74839>