INDUSTRY ANALYSIS

Industry Brief: Virtual Reality Readies for Business

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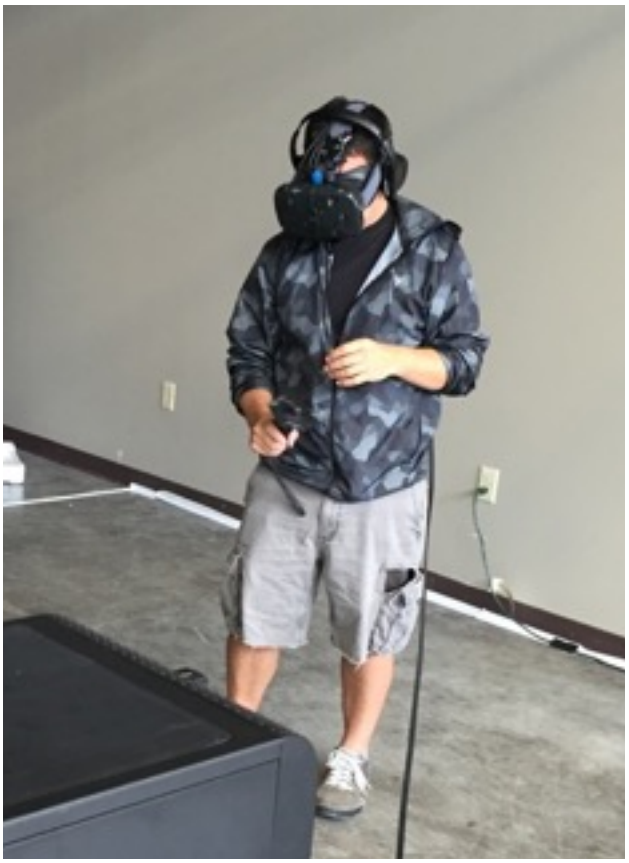
Over the past several months, the speculation about Oculus and its impact on computing have been running rampant. Facebook's acquisition and big demo lines at CES, E3 and other conferences have created significant hype for a product that doesn't exist beyond developer kits.

What are Virtual Reality and Augmented Reality?

Virtual Reality (VR) is a visually immersive technology that completely envelops the participant in a virtual world that "tricks" the brain into believing, and behaving, as if the virtual world was real.



There has been some discussion among analysts and journalists if virtual reality should really be recast for business because applications like virtual meetings aren't really virtual, they are real, you just attend virtually. But many applications of VR in business, such as training simulations, do create virtual, alternative realities where, for instance, handling hazardous material can be experienced virtually, eliminating risks associated with training in real world environments.

Augmented Reality, or AR, projects data and images atop the real world, often through projectors focused on the lenses of glasses. Augmented reality can also include overlays of data projected into real spaces captured, for instance, by tablet cameras. In this case, AR adds virtual elements to what the camera sees.

What Hardware Does VR Require?

VR currently requires a headset or goggles that completely cover the eyes of the participant, blocking light as well as external visual distractions. Much of VR also includes high-definition audio, and thus requires headphones in conjunction with the headset. The most sophisticated VR systems, like those from HTC and

Oculus, also offer controllers and an operating environment that either takes the place of, or significantly augments, existing operating systems like Microsoft Windows, Linux and Apple OS X.

The most basic VR experiences operate from a smartphone, often without a larger VR operating system, and without external controls, relying on visual "pointing" to invoke application level operations, which are usually limited to basic navigation. These systems usually require starting a VR experience from the phone, and then placing the phone into the headset. Switching applications usually requires removing the headset and starting a new application via traditional phone gestures, before reinserting the phone into the headset.

Systems like the Samsung Gear VR enhance basic VR environments with headset level controls that permit scrolling, clicking and backtracking, allowing a wider range of user interface activities and richer experiences. Further, the partnership between Samsung and Oculus creates an operating environment that offers fluid navigation between VR-specific applications.

Mobile vs. Tethered VR

VR currently offers two different classes of solutions: mobile and tethered.

Mobile solutions use mobile devices inserted into, or attached to the VR headset, to generate the VR experience. Ironically, mobile solutions are usually experienced in a stationary (seated) position. This is because current mobile solutions only track basic head movements. They lack position tracking for the user. Examples of this technology include Samsung Gear VR, Google Cardboard and the Zeiss VR One.

Tethered experiences exist because mobile experiences cannot yet process the massive amount of data and sensor input required to generate high resolution, fluid VR visuals, and at the same time, track the motion and actions of a participant.

Tethered experiences connect a VR headset to a computer via a cable, but they frequently include body sensing, boundary setting and controller technology that allow people to wander inside of VR worlds with relative safety.

Safety is relative in that cleared areas set-up as VR spaces are safe, as long as they aren't entered by outside entities (like pets or children, or even co-workers) — but the biggest safety issue is probably the tether itself, which can become entangled with the wearer's legs or arms. Most tethered VR experiences deployed in rooms where the participant engaged in the VR experience will walk around, require another person in the space for safety reasons.

University of Washington's Tom Furness judges an entry at the 2015 Seattle VR Hackathon. He is wearing a tethered VR headset. Photo: Daniel. W. Rasmus

What is the Value of VR to Business?

Virtual reality will provide value to business at multiple layers. At the basic level, it will provide incremental education, productivity and operational enhancements. At the next level, VR will provide for qualitatively enhanced collaborative experiences. At the highest end, VR will provide net new capabilities in a number of areas including marketing, engineering, and research and development.

There are significant limits to existing technology when it comes to interactions with representations of virtual things, as most of the time those interactions are limited to 2-dimensions.

Consider an Excel graph, even a 3D one, and although we perceive it as 3-Dimensional, in reality, we are looking at the dimensions through a 2-dimensional lens. We can spin and tilt the graph, but we can only see it from the front-facing position of our screen.

Now imagine that same graph in virtual reality. It will be floating perhaps, just before us. Using a mobile platform, we may need to be seated, but instead of just looking at the data, and seeing it from the outside, we will be able to tap a control and move inside the data. We will be able to look at the data on either side, months for instance, and leap from one to another. The details of what is in a bar may well be written on the side of the bar like graffiti.

If we go with a tethered room version, we can imagine actually walking around the data. If you think of a multi-dimensional bar graph with X, Y and Z axes, it is possible to hide a part of the graph if it is tilted incorrectly. Coexist with the graph and it becomes a kind of virtual corn field of data, something that can be explored by strolling through it. Big data analytics could use this type of representation to allow human analysts to wander through data, looking for patterns, even overlaying and integrating other data, as well as sharing insights with others, for instance, by commenting directly on the data representation, which will offer a new type of collaboration capability.

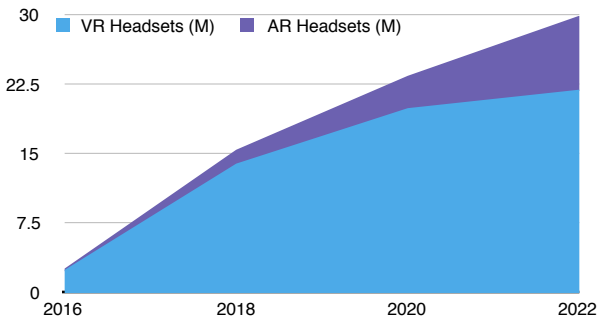
And those are just examples of Excel. Will they provide value? I'm sure for some. But there are many other three-dimensional activities that take place in business where two-dimensions just won't do. These include physical design of parts and assemblies, facilities (factory floors, retail floors, and offices) as well as physical experiences, that are often simulated either using real people or materials, at often big price tags, or might be dangerous to those involved.

Think about training a customer service attendant in an ice cream store. If they watch a video, or even play a simulation, all things will be forward looking. If they turn around, all they see is the real world, and the simulation breaks. Put the same trainee into a virtual reality training program where he or she hears a crash behind them while working with a customer, and then sees ice cream spilled all across the floor from a smashed container. How they prioritize, and how they stay focused when a workplace disaster is happening behind them at the same time they are trying to meet a customer's expectations can all be "tested".

VR/AR Market Sizing

Any speculation about the size of the VR or AR market at this point is just that, speculation. The Serious Insights forecast intends to give a general shape to market shipments rather than an actual prediction. We believe that the market will take off slower in the 2016-2017 timeframe than many predict, but that there will be a precipitous rise after that. If augmented reality technology makes major inroads by 2020, it will start to slow the VR curve and will eventually cannibalize VR marketshare after 2022.

Based on research into use cases, if key issues of personal and social integration are overcome by AR, then the AR market is likely to dwarf the VR market over the long term, but the solutions to those issues remain on the horizon. VR, however, does offer several intriguing business applications, especially in sales and training, that will create a vibrant market, but that market will rely on the adoption of VR by existing hardware and experience developers over other technologies like video. VR will re-



VR/AR Forecast 2016-2022. Source: Serious Insights LLC

quire a fundamental rethinking of many training experiences, thus much of the early market will focus on development of software to meet business experience delivery demands, not the selling of the experience itself. The market will likely evolve in stages, with small VR developers attempting to convince larger firms of VR's marketing and education potential. Some will invest. Alternatively, some large firms may initiate their own VR-related development efforts.

The magic ring or killer app for business won't be clear until there is mass market acceptance of VR. It is unlikely thatVR headsets will become ubiquitous horizontal platforms as in the case of tablets, though companies like Envelop VR are investing in technology designed to create the components for virtual office experiences, including multiple monitor,s projected input (being able to see hands and keyboard) and the integration of VR with traditional business software and operating systems.

The adoption wave will likely include two prongs, one focused on enhancing traditional work experiences, like using Windows or Mac for development or data monitoring, and the other, will be net new VR experiences that replace or augment activities like training or sales. Some people will be "working in VR" while others will be using VR as an occasional tool.

The ubiquity of VR in the long-term remains in doubt, as it is likely that AR hardware technology may well mature first.

The use case section at the end of this report details several other examples.

What Does Virtual Reality Need to Do to be Ready for Business?

Serious Insights has identified eight issues that the virtual reality market must address. These issues should be considered impediments to the effective adoption, use and acceptance of VR by business users.

1. Extend enterprise software. If VR is to succeed, it must include enterprise software. This means that traditional 2-dimensional clients, such as those from Microsoft, SAP, Salesforce, Cisco and others, will not only need to work within VR environments, but will need to leverage the capabilities of those environments to add new value.

2. Integrate real world feedback. VR employs real world feedback from embedded sensors in clothing, furniture and physical sur-

EnvelopVR's demonstration of "infinite" monitors in a virtual space. Source: EnvelopVR

roundings. This feedback will need to be bi-directional. A network of sensors is needed to provide VR environments with the data necessary to create a sense of touch, edge, contour or texture. When used for remote work, VR must be able to integrate vibrations or local sounds so that simulations provide all the necessary inputs for learning, and all the required cues for operations.

3. Create useful experiences. Business software must immediately provide the business user with the connection between their work and the value the software brings. VR must strive to do this as well. Demos that emphasize consumer scenarios, or those that offer too fanciful business opportunities with no proof for an ability to deliver an actual solution, will not create success for VR. It is important that VR developers balance between the wonder that VR can deliver, and the practical use of the technology in business scenarios.

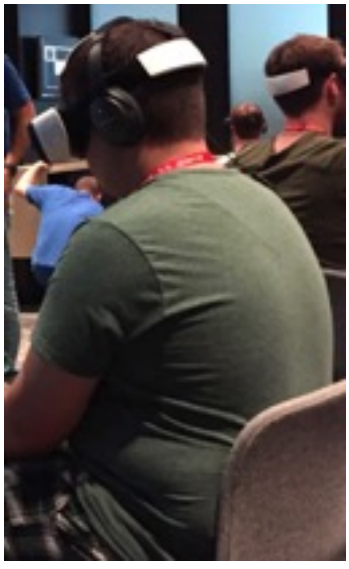
4. Address fine control, precision, and tools. Physical controllers don't yet provide the fine control that is required for true business applications. One of the classic use cases is that of collaborative design on a physical object. Interfaces do exist to permit some collaborative experiences, but very fine control of input — moving parts in a model, precisely changing parameters and applying detail — is beyond existing controllers. Innovation does exist, such as that coming from Leap Motion, which is focused on mapping human hands into the systems using their sensors and software. The the integration of existing tools, however, from stainless steel wrenches to sophisticated diagnostic equipment, remains elusive. Some applications will need to wait for augmented reality to mature, but a key market for VR is technical training, so VR must be able to deliver tools into the environment that not only train mental muscles, but help users obtain precise physical skills as well.

5. Provide accurate models. VR developers will need to learn quickly to integrate with existing business data, including 3D data, such as that from facilities systems and from Computer Aided Design (CAD), as well as other spatial relationship data, that will increase over the next several years as connected sensors become more prominent for monitoring everything from environmental factors to traffic patterns. VR models must produce accurate physics, and non-abstracted renderings when it comes to the representation of real world objects.

6. Deliver the right operating system metaphor. VR is richer than a windowed-PC environment, which provides for many more metaphors to choose from. In these early market stages, there will be an evolutionary testing, learning and discarding. Some will see convergence on an operating metaphor as a quick road to stagnating innovation, but it is likely the path to wide adoption as PC-based windowing environments and icon-based tablet environments have demonstrated.

7. Overcome hype and social stigma. Sometimes people don't want to be associated with trends, and they regard those that do as disingenuous. Many people also believe that when a new technology arrives, there is a conspiracy of influence as various interrelated parties reinforce messages in hope of creating a tidal wave that sweeps the idea into the mainstream. And sometimes technology does its own disservice, overly rationalizing its own downsides at the cost of authenticity.

Virtual reality is at the point that its advocates must be very cognizant of these economic hype and social stigma issues.



In terms of hype, many analyst firms, including this one, have considered VR worthy enough to generate pages of commentary and analysis. Lines stretch around game and electronics show floors for a fleeting moment with unreleased platforms. VR is just starting to make its presence

felt at business events beyond the entertainment industry. Even if the hype is true, VR will likely take off in entertainment first, which may well reinforce negative perceptions outside the entertainment industry as to the seriousness of the technology to offer real business solutions.

Google discovered the negative perceptions of AR when their Glass prototype generated "glasshole" as a derogatory description of a person wearing the augmented reality glasses. People wearing VR headsets are already subject to satire on television commercials and television shows. VR and AR, designers and developers need to realize that social acceptance, inside and outside of business, will highly influence its ultimate adoption of those technologies as legitimate business tools.

8. Avoid bad demo software. Much of the demonstration software, especially that designed for very accessible, low-end headsets, isn't very good. Low resolution images, static content and poorly designed navigation create a less than positive experience. High-end experiences have been limited to private or public demos at conferences, often with long lines that will deter typical business conference attendees. Hardware manufacturers who are currently driving content availability and distribution should be looking for quality, not quantity at this point. Unlike app stores where quality was able to overcome a large number of poor apps by employing user feedback and leader boards, VR content doesn't yet have that infrastructure in place, so picking a positive VR experience remains a crap shoot. If finding a good business-oriented VR demo is hard for business people, they won't look harder, they will just stop looking.

Other issues. Other potential issues that could slow business adoption include the failure to produce headsets that account for existing vision ailments, general dissatisfaction with headset weight and the tethered user experience, plus a lack of software that meets perceived business needs.

Why Should Businesses Consider VR an Important Competitive Capability?

As with any emerging technology, those who figure out how to leverage it most effectively first will be in a positive competitive position to create new value from the technology, and either displace incumbents, or, create a new barrier to entry from an already strong competitive position.

Here is a basic example. A residential high-rise developer invests in creating VR experiences for upcoming properties. This investment includes creating 3D models for the interior and exteriors of their planned properties, as well as models for the neighborhood, plus properties adjacent to their new development that would look on, and into, the new building. They also mine sources, from recommendation sites or law enforcement, for data regarding the neighborhood in which they are building.

The software team works with the developer to design the experience, including the role of lighting, and if virtual staging is available, different times of day should be coded, as well as a way to navigate through the various apartments. They may also look into voice talent for verbal overlays and self-guided tours. The talent may appear on screen, so they need to look into 3D scanning and avatar development. 3D video of local walks should also be captured so potential buyers can get a sense of the local businesses, pedestrian traffic patterns and general atmosphere of the neighborhood.

It is very clear that the VR experience is not simply a matter of showing a virtual building in a location, but creating a value-added experience for potential buyers. And what is described above all takes place before the development of the models begins.

If a developer of a property in the same neighborhood creates a traditional selling experience that requires models and showrooms, the VR experience will be differentiated on experience alone. It will also be differentiated in that it is mobile. Anyone with the right VR headset could plug into the sales presentation any-

where, anytime, and receive significantly more information than would be available from the best sales people in the most sophisticated on-site model.

The traditional-selling developer is clearly at a competitive disadvantage. The other developer is making a statement about their superior product by offering a superior selling experience. The traditional-selling developer will either need to invest significant amounts of money fora competitive platform, or they may decide to accept the alternative in longer sales cycles, a more constrained buyer pool, and perhaps even lower prices.

Many competitive scenarios like this simple example will play out in marketing and sales, and in education. Those who make the investment to deliver good, value-added experiences to customers and clients will be the early beneficiaries of the technology.

This does not imply that an early advantage is sustainable, because other firms can play catch-up pretty quickly as the technology matures and scale drives down the price of entry. Like many other instances where technology is involved, VR and AR will evolve from first-mover experiences driven simply by effective use of what is available, to the need, over time, to create differentiated use cases that will be difficult for competitors to develop;competition will come from a variety of sources including uniquely designed experiences that reinforce brand, and unique applications of data, perhaps even proprietary access to data, that others will have a difficult time replicating.

VR & Technology Convergence

VR will mature simultaneously with several other technologies, including artificial intelligence, in particular machine learning and vision, Big Data, the Internet of Things, 3D printing, neurological interfaces and remote-controlled vehicles, such as drones. Even areas like genomics will converge because a genome is essentially data, and the ability to visualize it and animate its behavior may reveal features or insights that can't be easily gleaned from existing technology. It is unclear what immersive visualization will bring to data insights in competition with machine learning, or perhaps as a way of augmenting it.

Big Data: New visualization and exploration capabilities will permit those analyzing data to perceive it very differently than do 2D representations. New interfaces will permit leaning into data and walking through it. Data relationship may be one of the biggest convergence areas with VR as clusters and outliers, and the thin threads of data that connect them can become a rich world within VR.

Internet of Things (IoT): Great potential for VR/AR-based control interface, as well as visualization of data and dashboards exist within IoT.

Machine Learning: It will be used to process data and to rapidly infer context.

Vision: Vision systems will be critical to VR in situations where visual sensors must map real world objects, including people, into VR systems. Beyond that, vision will be absolutely critical to AR as it seeks low latency alignment of data with real world objects.

External Neurological Interfaces: Emerging neurological interfaces currently require about the same space on a person's head as do VR headsets. The integration of these two technologies makes good design sense. By combining these two, entirely new modes of user interface controls could be developed.

3D Printing: Models developed for VR, or in VR, will have easy access to the real world through 3D printing. This will further blend the boundaries between the virtual and the real.

Robotics, Remote-Controlled Vehicles and Drones: These technologies will be important to VR on two-fronts. First, they will be the devices used to capture the real world in 360-degrees for use within VR software. Secondly, VR environments may eventually become the primary interface for controlling drones and other remote-controlled vehicles. Augmented reality will likely replace the heads-up display market in cars, making non-intrusive visual input avail-

able without regard to the price-point of a vehicle.

How Does a Business Get Started with VR?

Buy a system. Given that a basic mobile VR configuration will cost less than $1,000 (smartphone and headset), the first action is to buy a mobile headset. If you haven't had the experience, it is hard to imagine the possibilities.

Get familiar with the technology. Give an innovation team time and space to get familiar with the technology by using existing software. They may also want to engage in conversations with developers to understand the cost and time associated with customer solution development.

Experiment. Find an application that is aligned with the current capabilities of VR, your development budget and the talent of your staff or contractors. It is fine to push a new technology like VR to its limits, but that will already prove difficult for most entering into the space for the first time.

When will VR be Available to the Average Business?

Developer versions of Samsung Gear VR, HTC Vive and Oculus Rift are already available.

Samsung Gear VR will begin shipping in Fall 2015, with Oculus Rift becoming available in Q1 of 2016.

Many basic headsets, like Google Cardboard and the Zeiss One, are already available. More mature industrial designs from the likes of Vuzix and Epson have been on the market for several years.

How Much Does It Cost to Get Started with Virtual Reality?

Virtual reality basics will cost as little as $100 for a headset, with the cost of a typical VR capable phone running between $700 and $900. This is an extremely modest investment, and in most cases, someone on the team looking at VR will likely already have a compatible phone.

Tethered VR will likely start at around the $500 range, but those systems will also require at least a $1500 PC, and likely more, to drive the video.

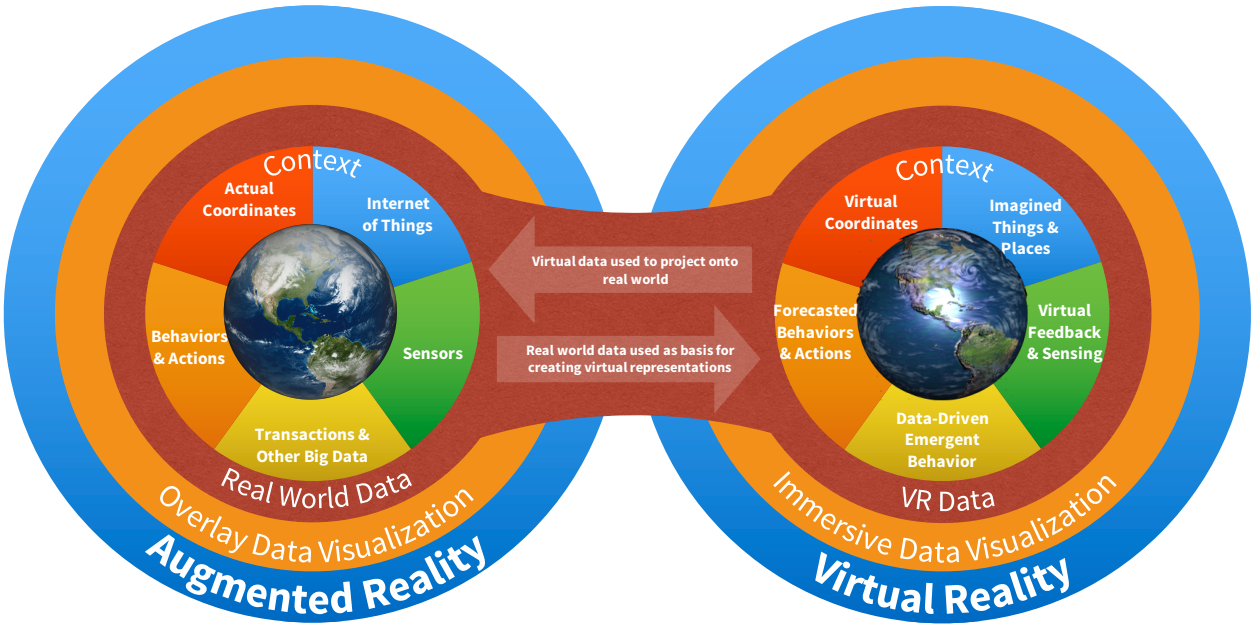
Unlike other technologies where prices usually fall after the initial product processes and materials are refined, and the economics of scale kick in, VR is likely to see price increases for second-tier products (those with sensors) and continue to rise over its first few years as additional sensors, better lenses and improved screens move into the hardware. Today's "good enough" experiences won't be "good enough" as use precipitates higher expectations for the technology. This will be especially true for mobile-driven hardware, but because tethered hardware relies on the same basic displays and sensors as mobile devices, the price of those headsets may increase as well—but as part of larger systems, which are already significantly more expensive.

How is Augmented Reality Different or the Same as Virtual Reality?

Virtual reality is one part of a continuum of experiences that starts or ends with the completely immersive experience of virtual reality, and begins or ends with the augmentation of reality with overlaid and blended data from various sources.

The fundamental differences in the two technologies are the displays, with VR being completely immersive, and AR being transparent so the real world can be seen through projections. Both technologies rely on data to create context, but virtual reality does this more easily because developers, designers and artists are in near complete control of the experience, and where the primary objects within a VR experience can be anticipated. Some secondary objects may be generated by data, and therefore, be self-determined or data-driven, but these will still behave within the constraints of the imagined world.

Augmented reality, however, must react to what is being seen at the moment, which means coordinating sensor input, including GPS and



Virtual Reality and Augmented Reality experiences will be driven by a conduit of real world transaction data extended into VR, while imaginative or speculative data will be projected onto real experiences, along with data grounded in actual transactions and profiles. Source: Serious Insights.

personal positioning—down to orientation and angle of the head. This is a significantly more difficult processing capability, but once orientation has been achieved, the data available for display is the same.

Using business recommendations as an example, the data from an online service like Yelp might appear above virtual representations of storefronts in a virtual version of a neighborhood. Because those business locations are predetermined within the simulation, the location of the data can be associated directly with the retailer, something similar to an RSS feed associated with a webpage.

In the real world, that same data would need to be displayed only after vision systems, sensors and location systems determine what exactly the person is seeing through their lenses. The data itself would be the same. This same principal applies to any other location-based data.

This becomes even more of an issue for the project of building models, for instance projecting a VR model of a building into real space, because all of the factors of location and personal orientation come into play, along with the need to project the model in proper orientation to existing structures.

Non-spatial data will will be less of an issue for AR, such as reading barcodes where the location of the physical object can be determined based on where the person is looking.

From an application standpoint, any virtual objects based on real world data, or data associated with objects, can be displayed effectively in either environment. AR can work well with any

An augmented reality example from Laster Technologies.

virtual object, be they building or machines or people, that recognize the constraints of the real world. VR can create completely alternative realities that have no basis in the real world, and therefore, any data associated with those models would be useless to AR experiences. VR will also be much more effective for simulation. If a building, for instance, is being tested for its ability to withstand an earthquake, simulating the earthquake will be an effective, useful and visceral experience in VR, and a mostly useful exercise in AR.

Who is Working on Enterprise Software for Virtual Reality?

Some companies, like Eon Reality, have been developing AR and VR applications for a long time. They have been around since 1999. The company offers solutions for industry, education and edutainment. They are a tool and solution builder. The Coliseum Product is a collaborative communications platform. They have a global presence with offices in North America, Europe, the Middle East and Asia. It is unclear how their existing technology will integrate with emerging AR and VR hardware and systems.

Established enterprise companies, like SAP, will also play a role. The company has created a 3D Visual Enterprise Solutions group.

Many early VR business developers are focusing on communications, such as AltspaceVR, that offers avatars for VR. Dora takes avatars into the real world by offering robotic control.

Some products, like Personify, which injects people into video presentations via Intel's RealSense technology, could easily become a VR-ready feature if sensors structure like from Occipital eventually brings 3D to realtime image capture.

Some hardware manufacturers are also software houses. Vuzix is a good example; the AR/VR firm also develops business solutions, for instance, for AR-based package identification.

Many start-ups, like Cubicle Ninjas, will be developing apps for business, while companies like Envelop VR, will be delivering platforms.

Where are the VR/AR Economic Clusters Likely to Emerge?

Based on video game development, which will be the primary source of development competencies early in the market as well as entertainment-based firms, the following areas are likely to become economic hubs for VR and AR.

Silicon Valley: General technology competencies, GPU manufacturer headquarters and access to social and financial capital.

Greater Los Angeles: Entertainment-based 3D visualization and modeling, animation, motion capture and other visual effects spill over.

Greater Seattle: A hub of the game industry with over 300 game developers, including, of

course, Microsoft. It is also the home of Digipen University and the University of Washington, both of which have strong gaming and VR/AR programs.

Vancouver: Strong game development and animation capabilities, along with strong ties to Hollywood production.

Other cities to watch include: Austin, Toronto, Boston, New York, Chicago and Montreal.

Countries to watch include: Canada, China, Japan and Russia.

Conclusion

Virtual reality and augmented reality are coming. The market is set to explode in early 2016, but businesses should be cautious as the software side of the market will primarily be focused on entertainment. Useful and effective business software will take awhile to appear, and at first, it is likely to be very niche oriented. Many early stories will be about internal training and education. The same stories of success will be repeated over-and-over. There is likely to be a negative undercurrent and many voices of doubt.

Eventually significant software for horizontal applications will appear, leading to new views of human-computer interactions. Other technologies, like "big data," may well spur market growth regardless of its adoption in other functional areas.

Businesses should be skeptical, but open minded. Don't launch into major competitive projects unless good partnerships are in place and there are solid contingencies plans. Make the first project something non-mission critical, but still important enough to prove value.

Recommendations

Manufacturers and Developers

- Integrate real world tools into VR experiences.
- Don't release "bad" software demos that poorly illustrate the potential of VR/AR or that make people ill.
- Ensure that people with various vision issues can be accommodated, either making it easy to wear glasses in the headsets, or by offering prescription lenses or individual adjustments for headsets.
- Listen closely to early adopter lessons and concerns and use them as learning opportunities. All AR and VR developers should consider themselves life-long learners as individuals, and learning organizations as a business.
- Create strong partnerships with a variety of headset manufacturers as first movers may not be the eventual winners, so software too closely tied to one manufacturer's model will be too risky early on.
- Recognize the spectrum of technologies within the VR and AR markets and keep both in mind when envisioning solutions.
- Partner with colleges and universities that teach critical skills such as realtime programming and "writing to the hardware."
- Develop hardware and use cases that integrate well with social situations, so that the lessons from Google class and the ascent of "glassholes" isn't a design issue repeated time and again in the market.
- Don't listen to investors who tell you to stay focused on the one thing they invested in your organization for — remain strategically aware of what is going on in the industry as it evolves, and be ready to adjust to changes in fortunes and perceptions.

Early Adopters

- Don't let the capabilities of systems or software early in the experimentation phase unduly influence the overall view of VR's potential. This is a nascent industry and if you get involved early, be prepared to learn and grow with it.
- Don't launch into major competitive projects unless you have great confidence that the application offers a real return.
- Experiment and learn.

Four Futures for VR & AR

Scenario planning examines the future through the lens of uncertainty and offers multiple, plausible perspectives. Scenario planning can take considerable time to get right. This report outlines the basic framework for four different futures based on two critical uncertainties: the integration of virtual experiences with the real world, and the geopolitical stability of the world.

Remember that in scenario planning the expectation is not for prediction, but for the description of plausible alternative futures that serve to challenge assumptions, suggest emergent behavior, provide new insights on existing knowledge, articulate a range of future states and outcomes, and provide the basis for ongoing engagement in monitoring the uncertainties in the model.

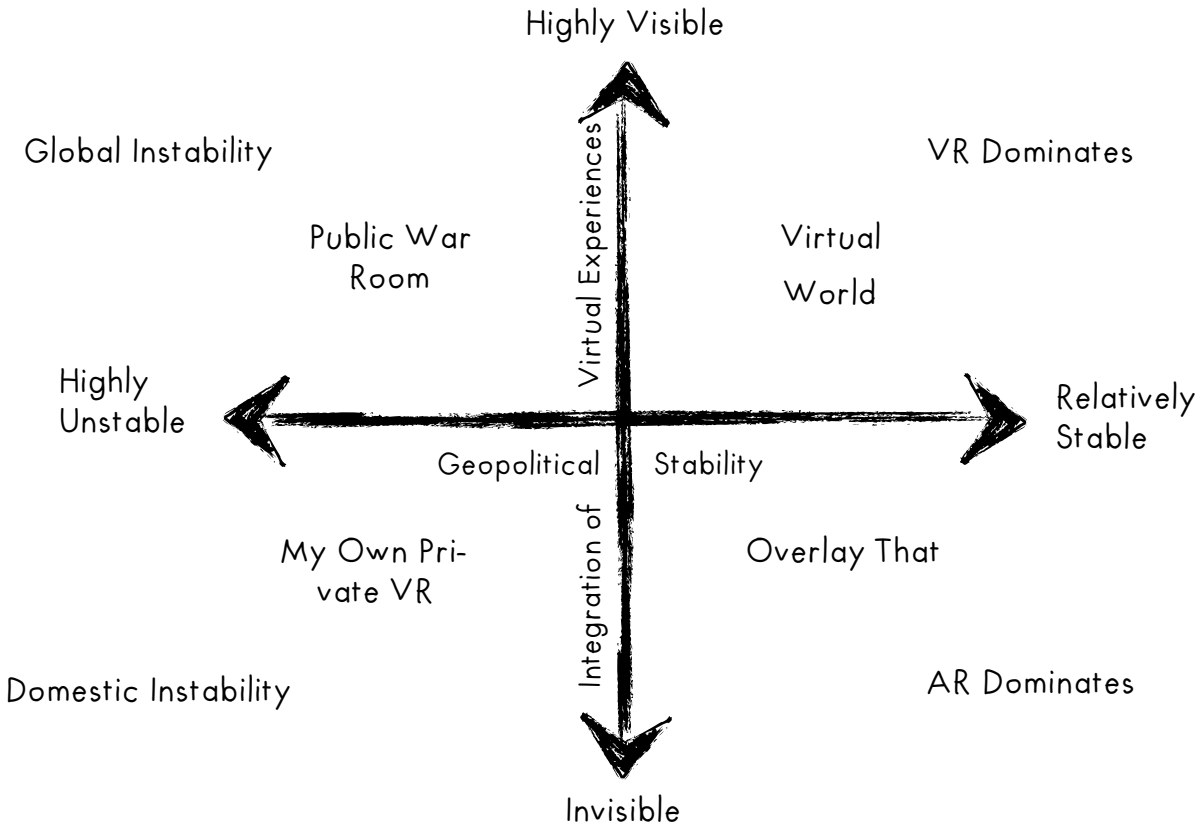
The Axes

Scenario matrices consist of two forces in play that are both highly uncertain, and critically important to the future of the market or concept under examination. The overlay of these two forces must generate extremely diverse futures in order to meet the goals of scenarios to adequately stretch and challenge existing conceptions of the future for that market or concept.

For these draft scenarios, the *Integration of Virtual Experiences* and the *Geopolitical Stability* of the world were chosen to drive the narratives.

Integration of Virtual Experiences

Virtual experiences are currently device-centered, meaning that a person in the real world typically interacts with a device in the real world to manipulate or interact with something in the



A matrix of scenarios for the VR/AR market in 2025.

virtual world. Any person looking over the shoulder of a person using a device, or in many cases just observing them, could see what that person was doing.

The advent of virtual reality and augmented reality creates virtual experiences where observers, in the case of VR, will know that a person is in a virtual space, but they will be unable to discern what he or she is doing. In the case of AR, people will be interacting with virtual spaces as well as data projected on the real world, but it will be increasingly difficult to know if a person is actively observing such an overlay, even if he or she is clearly wearing a device capable of such a projection.

Geopolitical Stability

In 2015, the world is seeing an increasing amount of violence, particularly focused on the Middle East and parts of Eastern Europe, but a recognition of first-world nations to their internal violence is also on the rise. Over the next decade, will the world be able to navigate toward a safer world, or will it continue in the sporadic, punctuated, geographically localized violence we see today? Or, will a major war erupt that creates global instability?

Additional Uncertainties

In addition to the uncertainties driving the matrix, other critical uncertainties exist that will possess different values depending on the scenario in which they are evaluated (until such time that an uncertainty becomes certain). It is highly unlikely that over the next decade definitive answers to these uncertainties will be derived, and even if the social consensus suggests that they have coalesced into a certainty, historical precedence suggests that the period of "certainty" or "stability" will not last, still rendering the items uncertain over the planning horizon.

Social

Family issues: Too much immersion. Less ability to monitor what software is being used.

Health: Effects on vision, cause of seizures.

The Virtuals (born 2000to present): What will be the demands, expectations and acceptance levels of the next generation of consumers?

Perception of privacy: How much of a threat do people perceive by providing their data to business and government? Do they remain willing to do so, or do they begin withholding data, and eventually sparking large social movements against access to private data? (This is a particularly crucial VR-related uncertainty because VR, and its related sensors and interaction models, will potentially be able to generate much more intimate data, in vast amounts, than any existing online interactions.)

Nature of trust: Do people trust technology?.Each other? The government?

The design of education: Does the disruption of education continue unabated, led by the disaggregation of teaching and new, more engaging models for learners, along with life-long learning, personalized learning and competency-based achievement? Or does education fail to effectively adopt new technologies, leading to less prepared consumers, a migration of jobs and a less effective use of technology in business?

Technological

How technology integrates with people: Will people continue to wear or carry technology, or will it become more embedded with implants, which may be able to augment organic sensing with digital sensing?

Internet of Things (IoT): What interfaces have emerged for the management of IoT and the use and interpretation of data coming from it?

Big data: Will "big data" become a major driver of computing and social experiences, or will push-backs in privacy curtail the rise of big data and its implications?

Policing hackers: Hacking will play a major role in issues of trust. If hackers continue to successfully infiltrate public and private institutions, and regularly cause damage to personal

data domains, there may be a general pull back from technology trust. The demise of hacking as a result of effective policing and technology enhancements could lead to much greater trust in technology, and act as a launch pad for many emergent technologies.

Role of game play in work and life: What role, if any, does gamification play over the next decade? Does much of work and life end up with some engagement and reward model, or does the fad fade, relegated to a few niche lifestyle or specific work experiences?

Safety of the Internet: Is the Internet perceived as a safe place to save personal data and conduct transactions, or do identify thefts, data breaches and other activities create a negative perception? Will islands of paid safety reemerge as the free Internet becomes an increasingly dangerous virtual place to live and work?

Strength of cognitive computing: While strong AI will likely remain wishful thinking over the next decade, many inroads may make AI, in particular digital assistants, a key component of virtual worlds. That adoption may drive use of AR and VR technology. Machine learning in the form of pattern recognition will be highly influential in the AR market for recognition of objects, perspectives and orientations, even without a more interpersonal cognitive capability. The failure of these technologies to deliver quality results within the VR/AR market may limit growth.

Efficacy of the cloud: Will the cloud perform unerringly, or will continued fails in cloud-based software service delivery wane from constant hacks, errors, and other infrastructure disruptions?

The personal computing experience: What will be the *de facto* interface to computing resources? Will a single platform predominate, or will a variety of devices and software platforms, as well as metaphors, fuel the next evolutionary leap in computing that create new competition, new stresses and new niches?

Trust of information: Has disinformation become so rampant that people no longer trust content, or have vetting organizations and better trained and more aware consumers, created an environment where information is trusted? Or has machine learning led to black boxes of validation that pronounce fact without the ability to verify?

Economic

State of the global economy: Is the global economy growing enough to drive the adoption of new consumer technology, or is slower growth a forcing function for the application of new technology to drive down costs? Either end of that spectrum promises growth for VR/AR as either a new gadget of choice, or as a technology of necessity.

State of the U.S. economy: Does the U.S. economy remain robust enough to allow it to continue to compete as the focal point for global technology innovation? Emerging markets like VR/AR are extremely vulnerable in their early stages. A concerted effort to create market leadership by China, for instance, could be a real possibility, creating a source of strong, potentially disruptive, competition.

Economic inequality: Do price points and economic inequality converge to limit access to AR and VR, creating new categories of haves and have-nots? Will VR/AR become a symbol of inequality?

Impact of technology on travel: Will technology, from VR to more sophisticated collaboration technology, reduce the need for travel? Travel will also be impacted by perceived safety and the price of fuel.

Character of collaboration: Will collaboration remain a 2D experience, or will VR and AR developers prioritize human-to-human, and human-to-virtual-object collaboration? Will 3D collaborative experiences become not just viable alternatives, but necessary for collaboration on physical objects like products or factories, or virtual objects, like data visualizations?

Model of organizations: Will organizations remain hierarchical, or will they become increasingly networked, flat or mixed in their rela-

tionship models (employees, contingent staff, contractors)?

Skill shortages: Will there be significant skill shortages that will create a "sellers market" leading to many workers dictating their geography and technology, or will much work remain geographically centered, driven by the choice of the organization rather than the worker?

Environmental

Access to rare earth elements: Will the basic elements necessary to manufacture sophisticated electronics become scarce, either through overuse and failures of recycling, or because the nations that own the mining rights decide to withhold them for economic or political leverage?

Natural disasters: Will increasing natural disasters create a new focus on technology that moves away from consumer consumption and toward sustainability, or will the "new normal" of climate change become a background story to optimize new opportunities created by it, and mitigating the associated risks?

Fuel prices: Continued low fuel prices will make travel attractive, even with acknowledgement of environmental impact. High fuel prices, or taxes that price environmental impact, would force organizations to consider alternatives to travel, like immersive collaboration. The wide adoption of an alternative to travel could also deeply affect the price of fuel.

Global pandemic: Will a global pandemic strike that eliminates the desire for much consumer technology? Or does such a disaster generate new needs for reaching remote locations with technology, and bringing together survivors in stricken areas?

Political

Geopolitical stability: See Axes above.

Privacy policy: Will the U.S. and Europe create such strict privacy policies that much of "big data" becomes either impossible or so impersonal it is useless? Or will privacy policy grow relatively neutral, with opt-in and self-policing as the primacy model, leading to ever more personalized experiences?

Advertising: As new technologies evolve, markets like advertising must explore how far they can go in interrupting or integrating with the experience. How will advertising assert itself into VR/AR? Will distractions be seen as public safety issues if AR becomes common? Will services allow opt-out paid subscriptions to services that eliminate advertising?

Public safety: Does AR in particular become a distraction that causes public safety issues as people get enamored with data when they should be paying attention to the world around them? Is public safety at a high enough level that people can freely use AR and VR in public spaces?

Scenario Sketches

The following sketches outline some divergent possibilities for the roles that VR and AR may play in 2025 against an array of social, political and economic backdrops.

Virtual World

VR and AR are everywhere. They are as socially acceptable as were smartphones just a few years before. VR lounges exist for entertainment and communications, as well as for illicit use, primarily in pornography and cybersex.

AR, while initially designed to assist in human decision making, has largely become a passive technology. Cognitive computing, driven by "big data," suggests most decisions to people ahead of their need to make them. Thus AR is simply the display technology. Anything a wearer sees has already been processed by his or her digital assistant. Increasingly, digital assistants become privately provisioned, no longer using shared data or shared infrastructure beyond compute and storage. Depending on access to personal data, assistants evolve at different rates. Different subscription plans either make newer learning models and insights available, or withhold them.

Public War Room

Global conflicts continue to cause strife across the world, including several terror attacks in the United States, which is also waging a cyberwar with China, Russia and North Korea. Iran has pulled out of its nuclear arms development agreement, but has done nothing yet to demonstrate any nuclear capability. Much of the Middle East is in turmoil as the ISIS Caliphate establishes itself across much of what was once Syria and Iraq, and stretching into parts of Saudi Arabia, Kuwait and Lebanon.

Virtual reality has become not only increasingly the way the U.S., Europe and Russia interface with their weapons systems — from drones to robotics — but they are also the way most Americans experience the war, with 360-degree views arriving from news drones in the air, and new robots on the ground.

Overlay That

Virtual reality is relegated to very specific user experiences, but augmented reality has become commonplace. People no longer need to look at their phones for the latest anything, because it just enters their field of view — and it does so at times, and in contexts, that machine learning has determined as appropriate or desired. Sensors in clothing and massive data from environmental sensors protect users from accidents, such as walking in front of automobiles while paying attention to a football gamecast on their AR headset. Some accidents still remain, however, as bandwidth and processing power still experiences interruptions or latency.

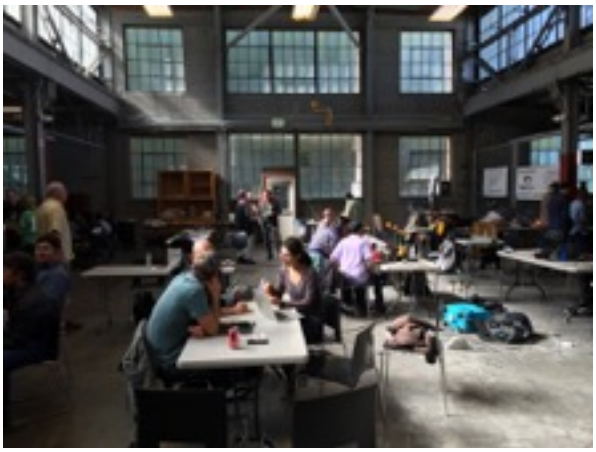
Cameras offer high-quality pattern recognition and voice control, so that smart phones have become more pocket computers, many of which only have basic screens for diagnostics. The wireless connection to headsets offers all of the necessary user interface elements to owners.

Almost all work has some form of augmented reality experience from mechanics seeing performance data when looking at a vehicle, to retail clerks who can verify a story by a person returning an item in realtime.

My Own Private VR

Safety is paramount, including personal safety and the safety of one's possessions. VR has become an escape and a trap. Because people no longer feel comfortable congregating at their local coffee shop, technology in tow, they now do so from home. This has exacerbated urban and suburban decay.

Virtual has replaced real, often even for people in the same room. People do still go to work, but because of the dominance of virtual interfaces and the reduction in social interactions, many firms provide VR to employees at work. Augmented reality is almost ubiquitous in retail.



Scenes from the Seattle VR Hackathon 2015. Photo: Daniel W. Rasmus

Experience Reviews

Over the course of the last several months I have had the opportunity to experience several virtual reality technologies. This section shares impressions of those demonstrations.

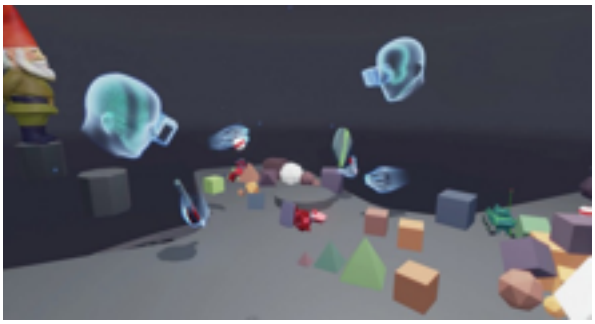
General impressions included the need for higher resolution displays, better controllers and more business-oriented demonstrations.

Oculus Touch

I experienced the Oculus Rift and Touch demonstration in a private session at PAX Prime 2015 in Seattle.

This was the best demonstration yet to spark my imagination about business applications. The Touch controllers offered a much more natural interaction model than the HTC "wands," however, putting on the controllers took some time and required assistance.

The demo was fluid, multi-user and, although some of the rendering was primitive, (see the illustration of the Toy Box section of the demo), the interaction between controllers and virtual objects suggested interactions in a way that should be useful for generating real world value. I was able to pick things up, punch them, stack them, toss them and shoot them. Perhaps the most compelling part of the demo was using a lighter to ignite virtual Roman candles.



Oculus Toy Box Demo

While the Toy Box showed a great deal of sophisticated modeling and relationship information, from flipping open the lighter to the flame aligning with the fuse, it still felt awkward. The flipping of the lighter and setting it down lit, often resulted in a lighter that fell over, unintentionally igniting nearby fuses. The design of the Touch controllers is elegant, but they are more focused on gaming than real world analogs, performing well in the game portions of the demonstration.

Overall, Oculus provided the best demonstration experience with a business perspective in that they created two-person scenarios and showed the relative ease with which representations of real world objects could be brought into, and manipulated, in the VR environment.

HTC Vive

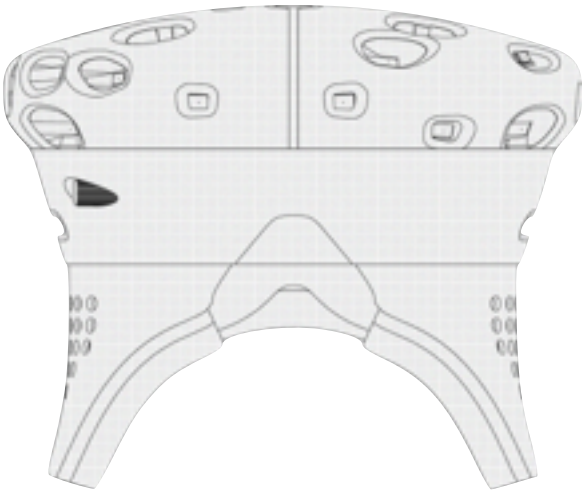
The HTC Vive, like the Oculus Rift, offered a series of demonstrations, many of which have been developed in conjunction with its early software development partners. I had the opportunity to experience the Vive during the PAX Prime 2015, and also during an Eve demo at the Envelop VR offices.

I found the visuals presented by HTC, in particular the interior of a magical cabin, the most compelling virtual reality environment from the atmosphere standpoint. It was particularly useful in demonstrating business applications, unless one happens to be a fantasy magician by trade. The one business-oriented portion of the demo, the construction of a machine, was presented more as a puzzle than as a demonstration of how VR could be used to successfully

guide someone to a conclusion. I was unable to construct the machine, which not only required assembly, but the reshaping of the components. Several times during the demonstration, my left control froze, leaving it stuck inside a component. This required a reset of the environment. I was told later this was probably due to an issue with batteries in the controller, which at this point in development, require regular replacement.

Rather than a gaming environment for assembly, I would much rather have seen a step-by-step VR instruction manual for something like an Ikea product. Imagine that a buyer could look at the assembly from any perspective they choose, versus from the perspective of a manual writer or video director.

The Apperture VR robot repair section of the demo pointed out the ability for the HTC Vive to render incredible scenes with great detail, but also the limitations of imagination when it comes to software development. Nope, I wasn't able to repair the distraught robot that looked to me for help, but the AR-like overlay projected onto the robot wasn't that helpful. As with the machine assembly, I would like to see a demo where the power for VR is used to demonstrate how the software can help solve a problem, not just present one in a different way.



Samsung Gear VR

Samsung provided me with the Gear VR and a Galaxy Note 4. The commercial version of Gear VR will work with Galaxy S6, S6 Edge, S6 Edge+, and Note 5.

The Gear VR experience, with the exception of an occasional pop-up, is completely separate from the normal Samsung Galaxy telephony experience. Gear VR cannot be managed outside of the Oculus operating environment, and you can't do normal things, like text, from within the VR environment. This demonstrates one of the early issues with VR, which is the lack of integration with existing systems and metaphors.

Oculus Home of a Samsung Gear VR Headset

Unlike the Oculus Rift and the HTC Vive demos, the Samsung demos have been self directed. Samsung VR gear does not require assistance to put it on or start the software. Insert the phone into the headset, attach speakers,

return the cover and put the headset on. The headset communicates with the phone to switch the operations mode to VR, and placing it on your head gets things going.

Samsung Gear VR, in its most basic form, does not include an external controller, but instead provides a basic scrolling controller on the side of the device, along with a back button. It doesn't take long to figure out the use of the controllers or where to find them on the headset.

Because the use of Gear VR was self-directed, I was able to load many different types of demonstrations with vastly differing levels of quality. The Oculus Cinema creates a virtual movie theater that once I loaded some of my personal collection onto the device, performed well. Seeing the pixels on the Galaxy Note display diminishes the experience with an engaging movie. While some of the video available in the Samsung Milk VR or the Oculus 360 Videos sections are good, others are embarrassingly poor.

Latency in the video isn't really an issue for high-quality, downloaded video, but it is with the selection of video. Select a video, and the software asks if you want streaming quality or high-quality. Selecting high-quality can lead to several minutes of waiting while the content loads, and in some situations, it doesn't remain resident, leading to the need for downloading the same content over and over.

This points to the lack of local storage assumptions by developers, as well as the lack of memory management software. Mobile devices with a 128GB SD card installed should be able to retain significant amounts of content.

The Oculus store provides both free and paid apps, similar to the Apple App Store or Google Play, although it isn't as mature in its business model. Applications downloaded do remain resident on the device, and like many Android apps, they require updates that need the attention of the user… yet another experience that doesn't make sense to put into the VR channel. I would rather see the VR apps update like other Android apps, outside of the VR app. Unlike content that usually stops downloading if the app is switched, apps continue to download updates in the background, but don't install automatically — and the downloads do effect performance.

As for performance, VR is a CPU and GPU intensive activity, for the most part. The "Cabinet of Curiosities" from the Cirque du Soleil show is one of the most immersive experiences in passive VR, with interesting things happing all around. Sit in a swivel chair for this demo. Unfortunately, this demo puts such a burden on the Note that the phone overheats and the experience shuts down for a cool-off.

Despite these issues, those who own a compatible Samsung phone and want to experiment in VR will find the new device a minor investment for the learning they will receive.

Zeiss One

The Zeiss VR One is essentially a basic VR headset of the Google Cardboard model, but with substantially better manufacturing and lenses—and it stays on your head without hands. This headset was shipped with a tray for the iPhone 6. Trays for other phones are available from Zeiss, or as downloadable files for 3D printing.

I found the headset comfortable to wear, and the style and design in-line with other headsets. As expected from Zeiss, the lenses are what sets this unit apart. Unfortunately, as has been noted in another review, the quality of the lenses magnifies the iPhone 6 screen so much that the pixels were very noticeable during use. This was the only headset that really created any sense of nausea for me, and that was probably due to the lack of quality demonstration software on the iPhone, combined with the inabili-

ty of the iPhone to feed the right frame rates consistently. Apple, unlike Samsung, isn't creating its own VR experience, though it is allowing VR apps into the App Store. While they may be bug and virus free, many of them offer very poor graphics and annoyingly bad navigation.

The Zeiss software itself doesn't work all that well, in that there is a basic loading area, but some of the applications require taking off the headset to provide a permission, and then reinserting it. Until Apple offers its own VR loading area, the iPhone will remain a second-tier platform for VR.

If you want to wander into the VR world from any phone, the Zeiss VR One is an inexpensive place to start. I wouldn't be surprised if given the high-end hardware from Samsung for the same entry price, that Zeiss won't drop their price soon.

A basic iPhone UI ready to be viewed in the Zeiss VR One.

Daniel W. Rasmus during his PAX Prime 2015 HTC Vive Demo. Photo: Pink Camera Media

Who are the VR Headset Makers?

There are a number of VR headset manufacturers developing products that will be released over the next 18 months. The following list attempts to be exhaustive, but the number of entrants to the market changes regularly, especially with the advent of crowdfunding approaches like Kickstarter.

Note that some links in the associated lists are news stories, not links to a manufacturer's site, as some headsets were prototypes and no direct site exists yet for them, and may not in the future.

VR Headset Manufacturers as of October 2015

Air VR	ImmersiON-VRelia BlueSky Pro
Archos VR Glasses	Microsoft Hololens
Avegant Glyph	MindMaze NeuroGoggles
Canon Virtual One	Oculus Rift
Cinoptics	Proteus Firefly VR
Cmoar	Razer/Sensics OSVR
Cordon	Samsung Gear VR
Dior Eyes VR	Sensics Zsight
Durovis Dive 5	Sony Morpheus
Emax X1	Starbreeze InfinitEye
Evomade Viewbox	Trivisio HMD
Fove Eye Tracking VR	Usens Impression PI
GameFace Labs	Visus VR
Goggle Tech Class	VR Union Claire
Google Cardboard	Xingear
Homido VR	Yezz VR360
HTC Vive	Zeiss VR One

What Types of Business Experiences will Virtual Reality Enable?

Virtual reality has the potential to play a key role in almost any industry. The simple ability to offer operations managers multiple, on-call monitors or dashboards means that any data-driven industry, from healthcare to energy, will find the price to deploy VR headsets into operational situations a cost effective alternative to buying and maintaining, and monitoring hardware. This basic data overload management opportunity applies to manufacturing, supply chain management, and retail merchandising.

The following table outlines some of the major use cases for VR in business. Some of these use cases may be equally useful as an AR experience. The last column suggests the best technologies for the experience.

Vertical Applications of VR and AR

Industry	Description	Category	AR/VR
Aerospace	Configuration. The visualization of a bill of materials for a particular configuration of a deliverable (as-designed, as-build, as-delivered, as-maintained, etc.).	Sales and Marketing	AR
Aerospace	Maintenance. Design maintenance procedures, define tooling needs and tolerances prior to building the first unit. Employ virtual designs to train maintenance engineers ahead of product deployment.	Productivity, Education and Training	AR/VR
Aerospace	Presentation. Allow potential customers to experience future products in a virtual environment as an alternative or augmentation of drawings, specifications and presentations.	Sales and Marketing	AR/VR
Aerospace	Product Design & Prototyping. Allow design teams to share a contextual experience for data, processes, including manufacturing assembly and test, and hardware mechanics. Provides feedback on operations and user experience early in the process.	Collaboration, Productivity	VR
Construction	Visualizing new construction: Exploring design options.	Sales and Marketing, Planning, Productivity, Safety	VR/AR
Construction	Viability.	Collaboration, Design, Planning	VR
Construction	Visualizing upgrades and refurbishments.	Sales and Marketing, Safety	VR

Industry	Description	Category	AR/VR
Consumer Products	Presentation: Virtual configuration.	Sales and Marketing	VR
Consumer Products	Product design and prototyping.	Collaboration, Design, Planning	VR
Consumer Products	VR Brand Experiences.	Sales and Marketing	VR
Energy	Facility design.	Collaboration, Design, Planning	VR
Energy	Practice disruption scenarios.	Education and Training, Productivity, Safety	VR
Energy	Resource exploration.	Data Visualization, Productivity	VR
Entertainment	Gaming and game-based tie-ins.	Sales and Marketing	VR
Entertainment	Visual effects production.	Productivity	VR
Enterainment	New viewing experiences.	Sales and Marketing	VR
Financial Markets	Service new markets by avoiding cost of in-country service centers.	Productivity	VR
Financial Markets	Visualizing market data and immersive trading environments.	Productivity, Data Visualization	VR
Financial Markets	Wealth management: visualization of complex investment portfolios.	Productivity, Data Visualization	VR
Government	Public safety services: Training.	Education and Training	VR
Government	Visualization of threat assessments.	Data Visualization, Productivity	VR
Healthcare	Anatomy simulation.	Education and Training	VR/AR
Healthcare	Close-in Neurological examinations.	Productivity	AR/VR
Healthcare	Dyslexia treatment.	Productivity	VR

Industry	Description	Category	AR/VR
Healthcare	Mental health issues: PTSD Treatment.	Productivity	VR
Healthcare	Sports Medicine: Motor skill improvement.	Data Visualization, Productivity	VR
Healthcare	Surgery: Remote surgery assistance, robotic surgery, AR surgery assistance.	Productivity, Education and Training	AR/VR
Hospitality	Time Share sales.	Sales and Marketing	VR
Hospitality	Visualization of conference and event spaces.	Sales and Marketing, Planning	VR
IT Services	Application development: “Infinite” monitors.	Productivity	VR
IT Services	Data Center Operations.	Data Visualization, Productivity	VR
IT Services	Data management.	Data Visualization, Productivity	VR
Leisure and Travel	Area and terrain familiarity.	Education and Training, Safety	VR/AR
Leisure and Travel	Interactive guides.	Education and Training, Productivity	VR/AR
Leisure and Travel	Travel to dangerous places.	Education and Training	VR
Logistics	Package picking and tracking.	Productivity	AR
Manufacturing	Production simulation and factory prototyping.	Productivity, Safety	VR
Manufacturing	Equipment training and qualification.	Productivity, Safety	VR/AR
Military	Battlefield simulation.	Education and Training	VR
Military	Battlefield medic training.	Education and Training	VR
Military	Equipment training and qualification, including flight simulation and other vehicle simulations.	Education and Training, Safety	VR

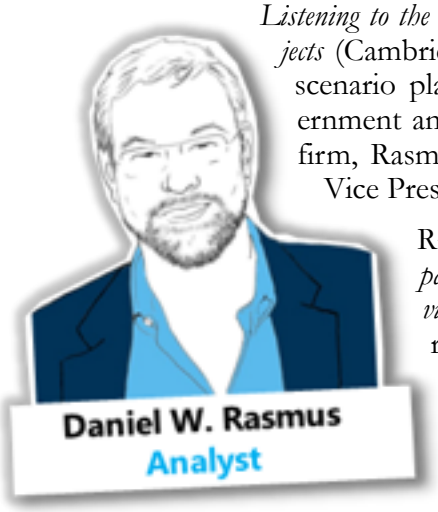
Industry	Description	Category	AR/VR
Military	Information enhancement.	Productivity, Safety	VR/AR
Military	Telepresence for military missions.	Productivity, Safety	VR
Military	Bootcamp enhancements.	Productivity, Education and Training	VR
Real Estate	Property previews and virtual open houses.	Sales and Marketing, Productivity	VR
Retail	Merchandise placement and floor simulations.	Sales and Marketing, Planning	VR/AR
Retail	Enhanced customer service.	Sales and Marketing, Productivity	AR
Retail	Virtual exploration of products on e-commerce sites.	Sales and Marketing, Productivity	VR/AR
Transportation	Accident analysis.	Productivity, Safety	VR
Transportation	Cargo organization.	Productivity	VR/AR
Transportation	Infrastructure design.	Design, Planning	VR/AR
Transportation	Traffic simulations.	Planning, Safety	VR

Horizontal Applications of VR and AR

Horizontal Application	Description	Category	AR/AR
Collaboration	Telepresence.	Productivity	VR
Collaboration	New models for interacting with physical objects like product and facility designs.	Productivity	VR/AR
Education	VR- and AR-based education experiences.	Education and Training	VR/AR
Personal Productivity	“Infinite” monitors.	Productivity	VR

About the Author

Daniel W. Rasmus is the Founder and Principal Analyst at Serious Insights LLC. He is the author of *Listening to the Future* (Wiley), *Management by Design* (Wiley) and *Rethinking Smart Objects* (Cambridge University Press). Rasmus analyzes the future of markets using scenario planning. He offers strategic advice and guidance to education, government and various technology and industry sectors. Prior to starting his own firm, Rasmus served as the Director of Business Insights at Microsoft, and a Vice President at Forrester Research.



Rasmus's comments on the future of work have appeared at *Fast Company, Harvard Business Review, Chief Knowledge Officer, African Business Review, KMWorld, Computers in Libraries and iPhone Life Magazine.* He writes regularly for *GeekWire* and *PopMatters.*

Rasmus is a member of the faculty academy at Pinchot University and an adjunct professor at Bellevue College.

Rasmus is also the author of *Sketches of Spain and Other Poems.*

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