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A PERSPECTIVE ON THE FUTURE OF ENTERPRISE AUGMENTED REALITY (AR)

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ABOUT INDEX AR SOLUTIONS

"We are augmenting people. We're making people more capable and more productive." –Dan Arczynski, President & CEO, Index AR Solutions during a Fox Business News live national interview on Risk and Reward.

INDEX LEADERS

Two former shipbuilding executives, Dan Arczynski, President & CEO, and Dexter Lilley, Executive VP & COO, manage Index. They retired from Huntington Ingalls Industries (HII), a Fortune 500 company and parent of Newport News Shipbuilding (NNS) to launch Index. With \$4.7 billion in revenue and close to 20,000 employees, NNS is best known as the sole designer, builder and refueler of U.S. Navy aircraft carriers and one of the two companies that can design and build U.S. Navy nuclear submarines.

Opening its doors in January 2015, Index is uniquely teamed with NNS and together boast a resume of more than five years of augmented reality (AR) research and development, and more than 50 "enterprise" projects. Index was born out of the industrial company's need to create and deploy enterprise AR technology. Immediately following its inception in 2011, the Index-NNS team quickly became a worldwide leader developing and deploying enterprise AR solutions on smart mobile devices to improve revenue, cost, schedule and quality performance.

Index believes that AR will change the way companies and their people serve all aspects of their value chain – from marketing and pre-visualization, to manufacturing and construction, to inspection, operations and maintenance. Early enterprise adopters will gain a significant competitive advantage over their rivals. Index plans to help enterprise clients leverage AR in their companies to gain that advantage.

INDEX APPLICATIONS

An Index AR application is an investment by an enterprise in its most valuable asset – people.

Index provides a full range of custom AR products and services to enterprise clients to include:

- turnkey AR projects and applications;
- Index's proprietary AR software;
- AR training;
- AR consultancy.

Engagements are highly collaborative, which helps the Client-Index team deliver an AR solution with the desired bottom-line results. Index relies on a dedicated group of AR engineers, designers, developers, graphic artists, trainers and human factor experts to best serve its enterprise clients.

READY NOW

Index AR solutions are "ready now."

An enterprise client can reach out to Index and within months have a turnkey AR "app" loaded on their devices. Prototypes, proof of concepts and pilots are good places to start as enterprise clients apply AR with their own information to their own processes and products to demonstrate feasibility and value. Then enterprise clients can move to projects, programs and production where the full top- and bottom-line impact of AR is realized. At Index we call these the six Ps.

Index is located in Williamsburg, Virginia, a pivotal city in another great revolution.



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PERSPECTIVES ARE OPINIONS. A POINT OF VIEW, AN ATTITUDE IF YOU WILL, TOWARD A PARTICULAR TOPIC.

This is the Index "Perspective on the Future of Enterprise AR." While it is very much an opinion, it draws on our collection of facts (statistics and metrics we've seen firsthand by enterprises adopting AR). It's drawn on understanding and experience gleaned over the past five years developing the teams and software needed to create and deploy AR for companies.

We invested the time into compiling and sharing this perspective because the results we've seen can help other companies navigate the waters of understanding of this disruptive technology and decide how and where to invest in AR to ultimately impact their top and bottom lines.

Because Index is a "pure play" enterprise AR company, and not a virtual reality (VR) or consumer focused company, you won't find discussion of VR or the consumer market (think Oculus Rift) in this perspective.

That is by design. It is not that VR and consumer products aren't playing a vital role in the marketplace. However, unlike other reports and analysis on emerging technologies that lump them all together, we know that enterprise AR alone delivers results and a perspective focused solely on that is valuable to decision makers.

Using Newport News Shipbuilding (NNS), a true pioneer in enterprise AR, as a role model, our study predicts that enterprises will begin in earnest the adoption of AR in 2017 and that it will take 15 years for all companies to adopt. Leaders and managers of large enterprise, industrial companies: This perspective is for you. Why? Because the Index founders realize, from firsthand experience as senior executives in large corporations, how difficult it is for an enterprise to embrace a new technology. Here we lay out specifically our view on "who, what, when, where, why and how" companies will (and should) adopt AR in the future. Consider it your roadmap.

The key takeaway from this perspective? DO NOT WAIT to understand the attributes and impact this technology can have on your company and competitive position. Index has seen it applied with dramatic top-line and bottom-line results. Take time to understand AR. Read, research, talk to experts or try a prototype. But whatever you do, do not ignore it. If you take the time to read this perspective, and we have done our job as authors, you will see why.

This study would not have been possible without the tireless work, insights and contributions of Edward Gildea; Consociate Media for helping us prepare this document for final distribution; and Matt Mulherin (President, NNS), Jennifer Boykin (VP, NNS) and Patrick Ryan (Manager, NNS) for their leadership in trailblazing AR for companies everywhere.

Sincerely, John Arczynski



II. EXECUTIVE SUMMARY

AUGMENTED REALITY (AR) HAS THE POTENTIAL TO CHANGE THE WAY EVERY COMPANY DOES BUSINESS.

- By 2026, for the U.S. Enterprise AR market, AR will account for an estimated \$49 billion in revenue (\$16 billion in hardware, \$6 billion in software, \$26 billion in services);
- By 2031, for the U.S. Enterprise AR market, AR will account for an estimated \$105 billion in revenue (\$49 billion in hardware, \$11 billion in software, \$45 billion in services);
- AR for enterprise is ready now. Within months, companies can deploy applications and evaluate AR and its potential impact;
- Companies can achieve double-digit performance improvement in terms of revenue, cost, schedule and quality;
- Every company and industry sector can benefit from enterprise AR to some extent. High-impact AR use cases exist in enterprise marketing, sales, communications, customer value enhancement, safety, quality, manufacturing, assembly, construction, inspection, logistics, training, operations and maintenance;

- Adoption of AR is different than other technologies in one major way. While other technologies (e.g. ERP, CAD, CRM) require large upfront, multi-year investments before value is realized, AR's value can be realized with the first and on every subsequent application.
- Multiple factors will drive the rate of adoption of enterprise AR. Chief among those factors are a company's strong understanding of the attributes and impacts of AR on its market and competitive position.
- Multiple high-impact AR uses developed and tested have already delivered top-and bottom-line results. Newport News Shipbuilding (NNS), is a trailblazer in enterprise AR and saw this impact, providing a standard for other companies to emulate.

Note: The focus of the Index perspective is USA Enterprise AR only. We expect the global market to be greater than the USA, but lack the client experience required to offer a meaningful perspective at this time.



III. BACKGROUND, SCOPE, IMPACT AND PURPOSE

A. BACKGROUND

An electrician holds a smartphone up to the wall, seeing the building's electrical systems without having to punch a hole in the wall. Construction workers building a factory complete the job without blueprints or drawings and carpenters frame a house sans measuring tape. Heavy equipment operators see where every feature is and how it works without cracking open their operating manual.

In all of these cases, industrial workers augment themselves with smart phones and tablets, allowing them to see the information they need to perform their job overlaid precisely on their building, factory, house or car.

To augment is to make something greater by adding to it. These workers, in very real use cases, utilized AR, which is the ability to overlay digital information on a physical space. In enterprise industries, that digital overlay of information is used to perform tasks, complete jobs and enhance people.

AR, once thought of synonymously with VR despite key differences, grew popular from specialized use by gamers and the military. Today, as described above, AR has moved to ubiquitous use by anyone with a smart device.

In industry – particularly in companies with large workforces – this technology has the potential to drive massive progress for employees, companies, job creation and national economies. That is because AR is an investment by companies in people to make them more capable and productive.

IT'S A REVOLUTION, IN MANY WAYS.

Throughout history, there are many examples of how disruptive technologies like this have changed how companies do business.

In the early 1700s, the steam engine arrived, disrupting how machinery was powered. No longer did industry have to purely rely on water wheels, windmills or animal power. Steam became foundational to the industrial revolution, changing everything. What took months before turned into weeks, weeks to days and days to hours. More could be produced faster, cheaper and with greater quality.

The results of AR being seen by early adopters are just as startling – revolutionary even. AR eliminates non-value added processes, like those mentioned above, to deliver dramatic customer engagement, cost, schedule and quality performance results. The positive outcomes from applying AR spans all aspects of a business's value chain and competitive position, impacting its top line, bottom line and balance sheet.

AR is ready now for large-scale enterprise implementation, and is being tested and deployed by industry leaders such as Virginia-based Newport News Shipbuilding (NNS), a division of Huntington Ingalls Industries (HII). There, engineers are tackling complex challenges every day with great people and innovative AR solutions. AR applications are developed to support the entire life cycle of aircraft carrier and submarine production and maintenance to include pre-visualization, stepby-step work instructions, part placement and inspection. The possibilities for high-impact AR solutions in industry are far-reaching because the ways to overlay information and data on a task, process or enhancing a customer product are countless. Information could be static or dynamic, preloaded or streamed, for display or interactive. Information can be written, electronic, graphical, voice, video, tables, policies, procedures, work instructions, engineering models, 2D or 3D. Through test prototypes, proof of concepts and pilots, companies can determine the best possible way to apply AR to their business model.

That is why AR holds even greater promise for enterprise than the consumer market. Companies have already created significant proprietary data. AR leverages this same company data to augment employees and customers, thereby improving the customer product experience and improving a company's cost, schedule and quality performance. Which is why the definition of augment – "to make something greater by adding to it" –describes this new technology revolution.

B. SCOPE

One clear objective of this market perspective is to separate AR from VR, as well as the consumer market from the industrial market. It is imperative that decision makers in business, government, unions and other organizations understand the impact this technology will have on their employees, customers, markets, competitors, partners and shareholders. As a result, the scope of this study is, "Enterprise Augmented Reality."

It is important to note that AR is not VR – although many confuse the two. AR is the overlay of digital information on the "real world." With AR, the real world is still there, but enhanced or augmented with additional information. With virtual reality, an artificial environment or world is created using data a person can interact with inside of this virtual reality or "near reality" world.

One reason for the confusion between AR and VR is past market studies combined AR and VR technologies, as well as combined consumer and enterprise markets. This perspective starts with the premise that AR and VR are fundamentally different technologies and their impacts on the consumer and enterprise markets will be dramatically different. This study focuses solely on AR technology and solely on its potential impact on the enterprise market over the next 15 years.

Furthermore, the consumer AR market is not the enterprise AR market. In the consumer market, the current focus for AR is entertainment and marketing of consumer products. Its dynamics, segments and economics are fundamentally different than the enterprise market.

As a result of focusing on AR and enterprise only, this perspective explores the positive economic impact of AR on workers, companies, industry sectors and the overall economy. Additionally, appropriate proxies can be identified to help forecast growth in the three major market segments: AR hardware for enterprise, AR software for enterprise and AR services for enterprise.

C. IMPACT

This study looks at AR from the point of view of the companies considering whether or not to adopt it. Identified here are eight high-impact uses of AR that will drive a company's top-line, bottom-line and balance sheet results:

TABLE 1

USES	IMPACT	EXAMPLES		
MARKETING,	Top Line	AR Maps that rise 3D off a table or pop up banners communicate with customers and		
SALES & COMMUNICATIONS		employees and recruits through text, voice, video, or other means in an interactive and		
		intimate way. Deployment is limitless and could include facilities, products and capabilities,		
		driving increased and differentiated sales.		
CUSTOMER VALUE PROPOSITION	Top Line	Owner manuals converted to AR for automobiles, heavy and light machinery, medical		
		instruments, tools, complex consumer and business products. The value of the product		
		is enhanced in the eyes of the customer. Companies can capture this increased value in		
		revenue, price, loyalty and other ways.		
SAFETY	Bottom Line	A 3D overlay of warnings over safety concerns or obstacles in the workplace, which could be		
		visible or invisible to the worker. Toxic gases, high voltage, tripping and falling hazards could		
		be highlighted with accompanying safety instructions to reduce accidents and lost time.		
MANUFACTURING &	Bottom Line	In situ 3D pre-visualization of complex work spaces or work sites showing multiple systems		
CONSTRUCTION		such as HVAC, piping, electrical and others to prevent installation sequence errors and		
		reduce cost and schedule while simultaneously improving quality.		
INSPECTION	Bottom Line	Overlay the 3D as designed models on the actual as-built-on-site, within a space or on		
		equipment, machinery or task, or other components to ensure quality and completeness quickly		
		and accurately. Inspection is often a best first-use case for AR across many industry settings.		
LOGISTICS	Bottom Line	Moving people to jobs or helping people find and select the right parts and components		
		can be enhanced with animation and overlaid directions pointing the way. People efficiently		
		navigate their way to their work location the first time and every time. Directional cues can		
		lead logistics personnel to the right parts and components under any condition, inside		
		warehouses or outside on site.		
TRAINING	Bottom Line	Our brains are wired from birth to learn better in a 3D world with 3D visualization. AR can		
		bypass 2D textual instructions with intuitive 3D teaching instructions that have proven to		
		reduce training times by as much as 50 percent.		
OPERATIONS & MAINTENANCE	Bottom Line	Complex start-up, shut-down and emergency procedures can be converted to simple,		
		visual step-by-step instructions that are easy to learn and understand the first time and		
		every time. Troubleshooting guides can be created using 2D and 3D animations to		
		reduce time to solution.		

Per the table above, AR applications can have a high impact on the following for a company:

- top line revenue (marketing, sales and customer value);
- bottom line cost, schedule and quality (safety, manufacturing, construction, inspection, logistics, training, operations and maintenance).

Over time, managers, engineers and workers in every company will develop and use their own high-impact AR solutions to solve their most pressing challenges and create significant value.

The following is a table that maps these eight high-impact AR applications against the industry sectors where positive returns on investment are expected:

It is important to note that AR is not VR – although many confuse the two.

TABLE 2

TOP LINE			BOTTOM LINE					
INDUSTRY SECTORS	MARKETING, SALES & COMMS	CUSTOMER VALUE PROPOSITION	SAFETY	MANUFACTURING & CONSTRUCTION	INSPECTION	LOGISTICS	TRAINING	OPERATIONS & MAINTENANCE
BASIC MATERIALS Chemicals Oil & Gas Mining Metals	ο	0	ο	0	Ο	Ο	Ο	ο
CONGLOMERATES	0	Ο	0	Ο	Ο	Ο	0	0
CONSUMER GOODS Appliances Automobiles Equipment Sporting Goods Toys & Games	ο	0	ο			Ο	ο	ο
FINANCIAL Insurance Investments Banking S&Ls Mortgages	ο							
HEALTHCARE Biotech Drug Manufacture Hospitals Med Appliances Med Instruments Long Term Care	Ο	0	ο			0	0	ο
INDUSTRIAL GOODS Aerospace Defense Machinery Construction Equipment Textiles Metal Fabrication	ο	ο	ο	ο	ο	Ο	Ο	ο
Services Advertising Airlines Auto Dealerships Broadcasting Department Store Education Lodging Publishing Railroads Shipping Sports Staffing Wholesale	Ο	Ο	ο			Ο	ο	Ο
Technology Software Computers Information Tech Semiconductors Internet Telecomm	ο	ο				Ο	Ο	ο
Utilities Electric Gas Water	Ο	0	ο	Ο	0	0	0	ο



Extrapolating the long-term quantitative impact of AR by application, worker, company, industry sector and national economies is difficult – especially at this early stage of adoption. One reason is that attributing performance improvements to a single technology is often misleading given countless other variables that affect worker productivity, a company's top line, bottom line and balance sheet, or a nation's economy. Also, if a new technology is providing a competitive advantage to a company, it is not in its best interest to share it broadly.

With that in mind, since 2011, one innovative company took the global lead in enterprise AR development and implementation – Newport News Shipbuilding (NNS). At NNS, the AR effort is led by Patrick Ryan, the Manager of the AR team, and sponsored by Jennifer Boykin, Vice President, Engineering and Design. As of 2016, with over 50 AR projects under its belt, NNS established an unparalleled leadership position in industrial AR.

Implementing an emerging technology that few understand in a large company is difficult at best. There were no enterprise AR practitioners to draw on, so Ryan and Boykin created a team of engineers, designers, software developers, graphic artists, trainers and even human factor professionals and trained them in AR. Concurrently, there was no off-the-shelf AR software platform that could address their enterprise challenges, so NNS created its own proprietary AR software toolkit. As time went on, NNS realized there was no way to access commercial enterprise markets, so Index AR Solutions was created to commercialize this unique NNS project experience, AR team and AR software.

For a company to invest in AR, it must first believe that the benefits in terms of cost, schedule, quality, safety and other factors provide them an acceptable return on investment. There are a myriad of internal management, shareholder, employee, culture, experience and other qualitative variables that also impact how an enterprise implements a new technology like AR. Total returns must be greater than total investment or the investment will not continue. Therefore, in aggregate, the total productivity improvement (return) from AR must be greater than the total size of the AR market (investment) to sustain the market.

The lower the breakeven in terms of productivity improvement, the more likely it is that AR will be quickly and widely adopted by an enterprise. Below is a table of U.S. total labor as well as select productivity improvements. From today to 2026, we will continue to refine both the market forecast (overall investment in AR) as well as measurable company results (returns) from AR implementation to assess the sustainability of the enterprise market.



IV. ENTERPRISE AR ADOPTION

A. COMPANY ENABLERS AND OBSTACLES

Companies seriously considering AR should first critically examine company enablers and obstacles to see how they apply to their enterprise.

Below, find several high-impact enablers and obstacles that will accelerate and slow enterprise adoption:

TABLE 3

ENABLERS	EXPLANATION
ENTERPRISE AR IS	In a matter of months, custom AR Solutions can be developed for companies for their use as prototypes, proof of
READY NOW	concepts and pilots, as well as full-blown turnkey projects. Companies can apply AR to their products and processes
	today and study their results before proceeding with a full-scale rollout.
COMPANY DATA IS	Companies are invested heavily in collecting and creating digital content. This same content is used to create AR.
ALREADY CREATED	An example of this valuable data is 3D CAD/CAM models, data analytics and sensor data as well as text, audio, video,
	work instructions, operating and training manuals and other uses.
AR IS EASY TO USE	The user learning curve for deployed AR applications is very low and, unlike other technologies, age is not a factor.
	Utilizing data such as 3D work overlays, AR applications enhance a worker's ability to perform tasks reducing gross
	errors, improving quality, improving cost and improving schedule.
UBIQUITOUS SMART	Off-the-shelf AR-ready smart mobile devices such as iPhones, iPads, Android devices and others are readily available. Companies
MOBILE DEVICES	can use these devices for AR and eliminate the cost and effort of deploying specialized hardware and heads-up displays.
RELATIVELY LOW	Most companies have made, or plan to make, investments in their processes, work instructions, other data and smart
INVESTMENT	mobile devices. AR leverages these company investments that are already made to overlay this information on the
	employees' work. The investment to create AR is small when compared to these prior investments.
FIRST MOVER	There are two reasons why a company that moves early to implement this technology will gain a significant competitive
ADVANTAGE	advantage over their rivals. First, AR is a highly disruptive technology that results in significant top line, bottom line and
	balance sheet benefits. Second, deploying AR in a company does not take place overnight. By the time you see your
	competitor's results, they are years ahead of you.
EARLY ADOPTER	Companies that encourage innovation will benefit greatly from AR. An inquisitive culture will spend the time
CULTURE	required to understand the benefits of this disruptive technology.
EMERGENCE	Someone had to move first and that company is Newport News Shipbuilding, a 130-year-old shipyard. It is the largest
OF THE	shipyard in the U.S. with over 20,000 employees and \$4.7 billion in revenue and best known for its nuclear aircraft
AK ENTEKPRISE INNOVATOR	carriers and submarines. With five years of experience in AR, it has blazed a trail that other companies can now follow.



TABLE 4

OBSTACLES	EXPLANATION
LIMITED EXPOSURE TO ENTERPRISE AR	In industry, there is limited exposure to the full capabilities
	of AR. Most of what companies have experimented with
	or seen to date is consumer-and marketing-based AR
	applications. At best, companies are at the very beginning
	of a multi-year journey with few trailblazers to study.
WAIT AND SEE MENTALITY	As we discuss in detail in the next section, many
	companies are slow to adopt technology and will be
	slow to adopt AR. They want to see the results that others
	in their market have achieved with this new technology.
LACK OF VISIBILITY AND SHARING	First movers with a new technology are reluctant to share
	performance results they consider a competitive advantage.
	That will be the case with AR where companies will adapt
	proprietary work processes to fully exploit the benefits.
LONG HORIZON	It will take a company several years to fully understand
	and exploit the many benefits of AR. That's because the
	ways to overlay company data on work processes and
	products are limitless.
WAITING FOR HEADS-UP DISPLAYS	There is a misconception by some companies that
	heads-up displays are required to deploy AR. As a result,
	these companies are waiting for heads-up displays
	before exploring the capabilities of AR and missing the
	benefits AR brings today.

When it comes to implementation of enterprise AR, the enablers are numerous. Not only is AR ready now, but an enterprise can also develop and deploy a custom AR app on their mobile devices in a matter of months. If past is prologue, that company can see dramatic performance improvements by augmenting its people in a short period of time.

It is important to note that the obstacles to implementation listed above can be overcome. Each company has to begin with the task of understanding AR's attributes and impacts. Only time will tell exactly how enablers and obstacles affect the adoption of AR. In the meantime, it is important to settle on an appropriate theory to forecast the AR market.

An inquisitive culture will spend the time required to understand the benefits of this disruptive technology.



B. DIFFUSION OF INNOVATIONS

The speed or velocity in which an emerging technology, in this case AR, is adopted by industry is difficult to predict. There is no actual history to extrapolate, no perfect proxy to assume and no proven model to forecast. For this perspective, consider the Diffusion of Innovations theory, first published in 1962 by Everett Rogers, that describes how, why and at what speed an emerging technology is adopted.

In the chart below, for the adoption of new technology, Rogers divides the population into five groups: innovators, early adopters, early majority, late majority and laggards. Innovators, at 2.5 percent of the population, adopt first and so on until the laggards at 16 percent adopt.



TABLE 5

Source: Diffusion of Innovation, 1962, Everett Rogers

One cannot assume that companies fit nicely into one of these five groups. The attributes in Rogers' table above are attributed to individuals rather than companies. A company can have hundreds, thousands, or even hundreds of thousands, of employees and will have innovators, early adopters, early majority, late majority and laggards on its rolls.

For this AR enterprise market perspective, Rogers' theory needs adaptation. For example, instead of individuals who freely share information about technology, it is often in the best interest of a company not to share. Therefore, companies must go through a discovery process. The stakes are high. Companies that fail to adopt a critical technology in a timely manner can find themselves losing market share.



Fortunately, companies vary widely in their adoption of new technology. Some move fast to gain a first mover advantage and some move slow or never at all. And depending on where a company is in its own journey, a first mover for one technology can become a straggler on another. That is because a company has many drivers, some business related and some not, that determine how they make decisions such as the adoption of a new technology. As seen in the table below, Roger's five groups are adapted to provide a reasonable start point for this expanded definition of technology adoption for enterprise AR.

TABLE 6

COMPANIES		OUR STUDY DEFINITIONS
FIRST MOVERS	2.5%	These companies are "first movers. "They are first to understand the attributes of the technology and
		how to use it to their competitive advantage. They have a good sense of a technology's cost, benefits,
		potential and limitations, as well as its ultimate impact on their top line, bottom line, balance sheet and
		shareholder value.
FAST FOLLOWERS	13.5%	These companies are "fast followers." Once they understand results seen from innovators, they move
		quickly to understand the technology and its impact on their business. Return on investment is
		important, but these companies are able to proceed on business intuition of the expected ROI.
FOLLOWERS	34%	These companies are "followers." They will wait until the innovators and early adopters implement the
		technology and show measurable positive results. They are not leaders and will not gain an advantage
		from the technology. They will invest only when the return on investment can be proven beyond a
		reasonable doubt.
STRAGGLERS	34%	These companies are "stragglers." They will fail to understand the attributes of the technology and the
		benefits to their competitive position. When they see the followers implement the technology, they will
		cautiously attempt to copy with lackluster results.
THE LOST	16%	These companies are "the lost." They never understand the technology and its impact on their competitive
		position. If the technology is as disruptive as AR, the failure to act could result in their irrelevance in the
		marketplace.

A major driver of adoption is the degree to which companies understand, or fail to understand, the new technology and its impact on their competitive position. This requires an inquisitive culture and an upfront investment of time rather than significant capital. In early stages, a company uses prototypes, proof of concepts and pilots to determine if the new technology adds value. This knowledge informs a company how best to proceed with implementation.



C. BUILDING AN ADOPTION CURVE

A company's adoption of new technology does not take place overnight. Rather it takes place over many years and is influenced by company goals, performance, budget cycle, market factors, leadership and culture, as well as the success of the technology at every step of a rollout.

One unique aspect of AR implementation is that it is possible for a company to start small and then grow its AR capability over time. For example, a company can start with a single app that helps its workers with training. The upfront investment is the development of the AR app given that smart mobile devices are ubiquitous and company training content is available. In a few months, the company can enjoy the returns of reduced training time.

Since AR can start small and grow over time, its implementation has a different rhythm or steps than many other technologies. We call these steps of AR adoption the six Ps.

TABLE 7

SIX Ps	DESCRIPTION
PROTOTYPE	An AR sample that uses current client data and product. Timeframe is 4-6 weeks.
	Compare a current client process to a new AR-based process and demonstrate its feasibility and value. Timeframe is
PROOF OF CONCEPT	6-8 weeks.
	A small-scale effort and study to determine and evaluate key client performance factors and metrics. Timeframe is 1-2
PILOT	months.
PROJECT	A collaborative effort creating a targeted AR solution for client processes or products with explicit success criteria,
	such as showcasing AR, ROI or other solutions. Timeframe is 2-5 months.
PROGRAM	A rollout of AR solutions across a broad range of processes or products. Meaningful impact on revenue, cost, schedule,
	quality and safety. Timeframe is 1-2 years.
PRODUCTION	A full-scale rollout across the company. Significant impact on the top line, bottom line, balance sheet and shareholder
	value. Timeframe is 2-4 years.

With this approach, several principles apply to enterprise AR adoption. First, every AR app can stand alone. This is important to companies that measure their return on incremental investments. Second, every AR app builds and enables the next AR app. In other words, the first incremental investment becomes the foundation for the next and so on. Third, each AR app is part of an overall roadmap. Initial prototypes, proofs, pilots and projects build to and are foundations for the larger rollout of programs and production. This gives the adoption of enterprise AR a great advantage over the adoption of other technologies that are not effective until after a large upfront investment is made. For example, when a company makes the decision to adopt an ERP, CAD or CRM system, it embarks on a major multi-year investment that only pays off many years in the future. These decisions become great leaps of faith for companies and poor decisions only become apparent down the road. The six Ps strongly suggest an exponential adoption curve for each company. The adoption starts off small (prototypes, proofs, pilots and projects) for several years and then quickly picks up steam (programs and production). An exponential adoption curve is consistent with the chart below created by Nicholas Felton of the *New York Times* and republished in the *Harvard Business Review*. Felton not only demonstrates the exponential nature of technology adoption, but also that the pace of adoption is speeding up over time. The "six Ps" company discovery process will result in a similar "S Curve" for the enterprise adoption of AR.

TABLE 8

PERCENT OF U.S. HOUSEHOLDS



CONSUMPTION SPREADS FASTER TODAY

Source: Michael Felton, The New York Times

In the table below, the exponential curve reflects the logic of the six Ps. Whether a company is a fast mover or a straggler, when adopting AR they are likely to go through these six steps.



TABLE 9

Everything starts with the first prototype, the first time that an enterprise sees AR in its own environment in the hands of its own workers, using its own data, effecting its own processes and getting its own results. First movers will be the first to experiment with AR in a meaningful way. In this case, picking a strong first project that demonstrates the value of AR is key and a poorly executed first prototype is to be avoided. Referring back to the eight high-impact uses for AR, six are a good place to start for initial company prototypes:

- marketing, sales and communication;
- customer value proposition;
- manufacturing and construction;
- inspection;
- training;
- operations and maintenance.

The importance of success on early projects cannot be overstated when it comes to company adoption of a new technology.



D. RESULTING ADOPTION RATES

Fast movers will start first and the time they spend going from first prototype to production will be the shortest. Then will come the fast followers, the followers, the stragglers and, finally, the lost. The lost will start last and the time they spend going from first prototype to production will be the longest. The table below reflects this logic and serves as the basis of the following forecast.

TABLE 10

COMPANIES		START DATE	PROTOTYPE TO PRODUCTION	ADOPTION COMPLETE
FIRST MOVERS	2.5%	2017	3 years	2019
FAST FOLLOWERS	13.5%	2019	4 years	2022
FOLLOWERS	34%	2021	5 years	2025
STRAGGLERS	34%	2023	6 years	2028
THE LOST	16%	2025	7 years	2031

By 2017, the first movers will have started their first prototype. By 2019, they will be fully exploiting the value of AR. They will enjoy this advantage for up to a decade over many of their rivals.

Fast followers will also enjoy an advantage over most of their rivals, but followers will at best maintain their position in the marketplace. They will lose share and position to the first movers and fast followers and gain from the stragglers and the lost.



V. ENTERPRISE AR MARKET FORECAST (2017 – 2031)

A. THE THREE ENTERPRISE AR MARKET SEGMENTS

When an enterprise makes a decision to deploy AR, whether from a small prototype to large-scale production, it likely will have many of the key ingredients already in place – workforce, content and processes, among others. There are three things companies need to create AR and that is how this perspective defines the three market segments.

HARDWARE

To deploy AR, an enterprise needs devices – hardware – that can overlay information on the real world. Off-the-shelf smartphones and tablets have the technology today to create and deploy AR. AR-capable head mounted displays (HMDs) are part of this segment as well as hybrid devices.

SOFTWARE

An enterprise and/or its AR provider will use AR software to create the AR experience or solution. Over time, software will take many forms, such as custom, off-the-shelf, proprietary/ closed source and open source. Enterprise will demand software preserve data security, data integrity and IP creation.

SERVICES

Enterprise employees and vendors will analyze processes and products that can benefit from AR, then create and develop AR apps using AR software for deployment on AR hardware. Engineers will make up half of this population with other professions filling in the balance. As mentioned earlier, this perspective uses the AR team at NNS as a role model, which, in addition to engineers, includes designers, software developers, graphic artists, process experts, trainers and human factor experts.

B. AR HARDWARE FOR ENTERPRISE

While the adoption curve (Table 9) and the adoption rate (Table 10) are key assumptions, there are a few other assumptions required to forecast the spend for enterprise AR hardware. First, what is the addressable market? This study assumes a percentage of total employees will use AR and as a result require hardware. Second, what is the cost per user of the hardware? This will vary from smart mobile devices to hybrids to heads-up displays. Third, what is the ratio between smart mobile devices, hybrids and heads-up displays?

The addressable market assumption is that at full adoption by a company, the percentage of "user" employees using AR will be high. According to the Bureau of Labor Statistics, there are approximately 150 million employees in the U.S. With regard to full adoption, for a base case this study assumes 40 percent of total employees, for a low case 30 percent and for a high case 50 percent.

Every industry has at least one category of high-impact uses with a positive ROI (Table 2). Every company can benefit from AR in marketing, sales and communications, as well as in training, and many companies can benefit from maintenance of facilities, equipment, and machinery where uses are widespread. Given the predicted adoption curve and rate, the number of employees using AR is shown in the table below.

TABLE 11



POPULATION USING AUGMENTED REALITY

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Every company can benefit from AR in marketing, sales and communications.



The assumption for the cost per device is based on incremental cost. For example, the incremental cost of a smart mobile device to an employee is actually zero if the company has already issued them as part of a mobile device strategy. If a company does need to buy an incremental smart mobile device, we assume that cost to be \$500. The incremental cost of hybrid hardware to enhance smart mobile devices is assumed to be \$250 per device. Here a company could enhance a device with additional capabilities to include sensors, cameras, depth finders and/or object recognition and tracking. Finally, the incremental cost of a heads-up display is assumed to be \$1,500. It is assumed that hardware will be replaced every three years.

Finally, the penetration ratio between smart mobile devices, hybrids and heads-up displays will vary over time. In our view, 90 percent of the value of enterprise AR can be achieved with off-the-shelf smart mobile devices. As a result, it is assumed that heads-up displays and hybrids will at first each capture 5 percent of the enterprise market. Over time, this ratio will change dramatically with the increase of the value proposition of heads-up displays. By the end of the forecast period, headsup displays will account for 45 percent of the hardware market segment with hybrids remaining at 5 percent and smart mobile devices capturing 50 percent.

Over time, the mix between smart mobile devices already provided by companies and those that a company must buy to deploy AR will also change. Today, a company typically buys a new smart mobile device to deploy AR. As a result, it is assumed these make up 70 percent of the population in 2017 versus 20 percent already provided by companies. By the end of the forecast period, this mix will shift dramatically so that only 10 percent of the hardware market will require a new smart mobile device purchase while 40 percent of this segment is made up of devices already provided by companies with no incremental spend.

Table 12 displays the change in mix in the hardware segment between hybrids, heads-up displays, smart mobile devices purchased specifically for AR and devices already deployed requiring no additional spend.



CHANGE IN HARDWARE MIX, % OF TOTAL AR DEVICES

C. AR SOFTWARE FOR ENTERPRISE

Similar to hardware, there are several additional assumptions required to forecast this segment. First, what is the addressable market? Second, what is the cost per seat per year of AR software?

To determine the addressable market, this forecast looks at the experience of Newport News Shipbuilding (NNS), which, over the past five years, created an internal team of engineers, designers, software developers, graphic artists, trainers and even human factor professionals and trained them in AR. As a group, these are the professionals that use their proprietary AR software to author, develop and deploy AR apps and solutions. Roughly half the team members are engineers, which is the assumption used for the addressable market. In the U.S., as of May 2015, there are approximately 2.5 million people in architecture and engineering (now called engineers) occupations according to the Bureau of Labor Statistics. The ability to author, develop and deploy AR will be a capability that engineers covet. With regards to full adoption, for a base case this study assumes 20 percent of total engineers will be trained in and purchase AR authoring software, for a low case of 10 percent and for a high case of 30 percent. In 2031, when full adoption is achieved, approximately 550,000 engineers therefore will be active AR-authoring software users.

Doubling this number is needed to account for the other professionals that will help engineer, author, develop and deploy AR apps similar to our experience at NNS. The chart below showcases the 2017 – 2031 forecast of the users of AR software.

TABLE 13



POPULATION DEVELOPING AUGMENTED REALITY

This full adoption 20 percent base case penetration of the engineering population is a critical assumption that will be validated over time.

Cost per seat per year is assumed at \$10,000. This cost includes software as well as training and represents a blended cost of per-seat and per-site licenses.



D. AR SERVICES FOR ENTERPRISE

Similar to hardware and software, there are several additional assumptions required to forecast this segment. First, what is the addressable market? Second, what is the cost of the people required to author, create and deploy AR apps?

The addressable market for AR services is identical to AR software. These are the "boots on the ground" for enterprise AR. They will use AR-authoring software as well as their knowledge of company processes to create AR apps that make employees more capable and productive. They will use AR to change processes in order to improve safety and quality while reducing cost and schedule.

NNS, as a use case, built a team of engineers, designers, software developers, trainers, graphic artists and human factor experts and trained them in AR. Other companies will follow this model, licensing enterprise AR-authoring software and training select employees in how to author, create and deploy AR in their company. Companies will turn to independent AR service providers for additional capacity or expertise. One key assumption is that the individuals who provide this service, especially those internal to companies, do not spend 100 percent of their time working on AR. Rather, 50 percent of their time is spent on other responsibilities and the remaining 50 percent creating AR. For these individuals, AR will be one more arrow in their capability quiver.

The mix between independent AR service providers and company internal AR teams is an interesting question. Internal company teams will perform the majority of this effort in the latter years of our forecast. However, there is a significant need throughout the forecast for AR service vendors that can provide surge capacity as well as help with challenging projects or help companies get their AR effort off the ground. Depending on the year, this outsourcing to third party AR service vendors, like Index AR Solutions, could represent 20 percent to over 50 percent of the service market segment.

E. TOTAL MARKET FORECAST

This base case predicts that by 2031, the US enterprise AR market totals over \$105 billion, made up of \$45 billion in services, \$11 billion in software and \$49 billion in hardware. Over the 15-year period required for full adoption, growth is exponential.

TABLE 14

FORECAST BASE CASE

(\$ IN BILLIONS)	2021	2026	2031
SERVICES	\$3.4	\$26.2	\$45.4
SOFTWARE/TRAINING	\$0.8	\$6.3	\$11.0
HARDWARE	\$1.8	\$16.2	\$49.4
TOTAL	\$6.0	\$48.7	\$105.8

Services are a key and significant revenue driver for enterprise AR throughout the 15-year forecast. Although smaller, Software and Training are key enablers for hardware and service sales. Hardware revenue will see its greatest growth in the last five years, as HMD technology matures and replaces mobile devices.



ENTERPRISE AR HARDWARE REVENUE MIX

(\$ IN BILLIONS)	2021	2026	2031
MOBILE DEVICES - BUY	\$1.0	\$3.9	\$3.4
MOBILE DEVICES – IN PLACE	-	-	-
HEADS-UP DISPLAYS	\$0.7	\$11.9	\$45.2
HYBRID HARDWARE	\$0.1	\$0.5	\$0.8
TOTAL	\$1.8	\$16.2	\$49.4

F. CONCLUSION

Will companies in the U.S. adopt this game-changing technology faster than predicted here? The decision that rests with each individual company is when to make the investment required to understand and evaluate the attributes of AR and its impact on their respective businesses. The advantage of AR is that a small upfront investment in prototypes, proof of concepts, pilots and projects yields great dividends and understanding. Once companies realize that AR is ready now, there will be an acceleration of enterprise adoption.







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