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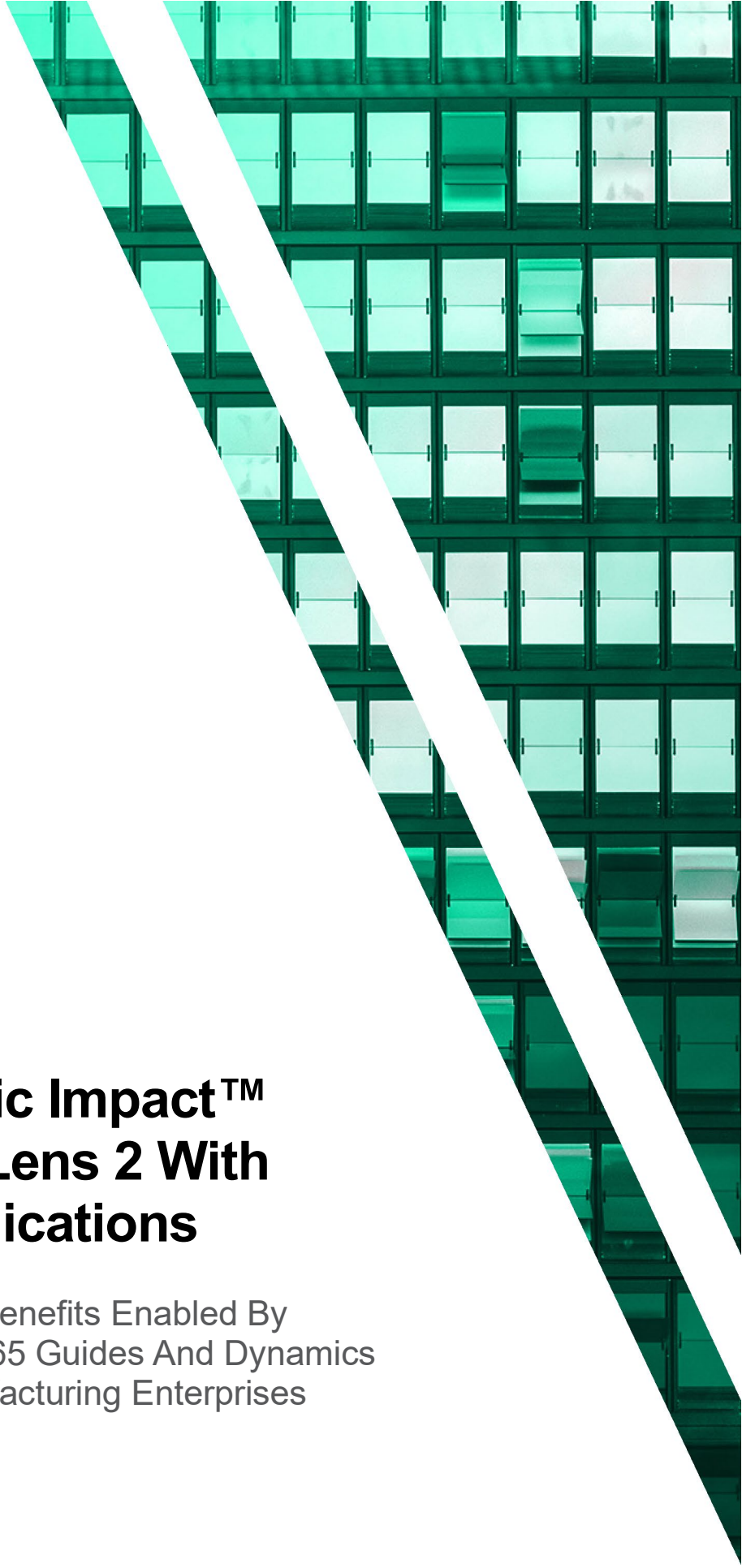

The Total Economic Impact™ Of Microsoft HoloLens 2 With Mixed Reality Applications

Cost Savings And Business Benefits Enabled By HoloLens 2 With Dynamics 365 Guides And Dynamics 365 Remote Assist For Manufacturing Enterprises

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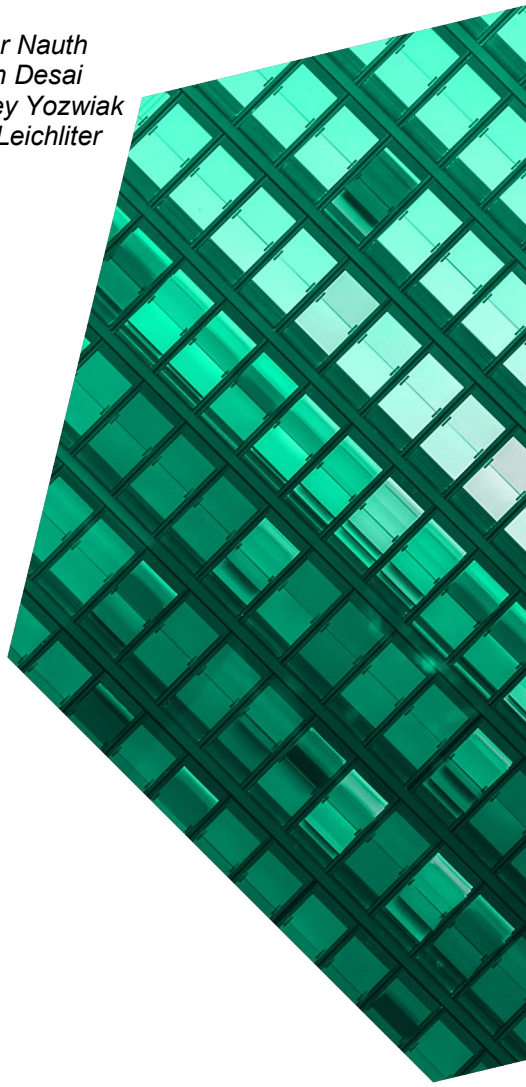


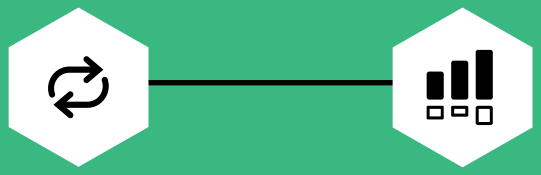
Executive Summary

Mixed reality, an immersive technology that overlays 3D visualizations, instruction, and simulations over real-world environments, has the potential to transform work. Microsoft's HoloLens 2 with first-party mixed reality (MR) applications is enabling manufacturing organizations to embrace the fourth industrial revolution, impacting training, manufacturing operations, and field collaboration, while accelerating time to revenue.

Mixed reality (MR) technologies enable modern workforces and are a key pillar for organizations who are embracing the fourth industrial revolution (Industry 4.0). Hands-free, immersive 3D overlays and visualizations provide manufacturing organizations with numerous opportunities to drive value with more effective training and enable remote collaboration to solve complex manufacturing issues. Mixed reality contains elements of virtual and augmented reality but focuses on holography. The user is sufficiently immersed to clearly see and interact with digital models and data, but not so immersed that they cannot do their work in the field. The transparent nature of the device allows the user to continue doing their work while also having a relatively realistic experience of the data, information, or models. MR has become an important tool in the toolbox for manufacturing organizations to deliver value and solve critical problems when they arise.

Microsoft commissioned Forrester Consulting to conduct a Total Economic Impact™ (TEI) study and examine the potential return on investment (ROI) enterprises may realize by deploying HoloLens 2 with mixed reality applications.[1] The purpose of this study is to provide readers with a framework to evaluate the potential financial impact of HoloLens 2 with first-party mixed reality applications on their organizations. It should be noted that the mixed reality applications discussed in this study are specifically Microsoft Dynamics 365 Guides (Guides) and Microsoft Dynamics 365 Remote Assist (RA), and not any commercial third-party or internally developed applications. While HoloLens 2 with mixed reality applications is applicable to numerous sectors, the focus of this study is on the ROI and benefits to manufacturing organizations.

KEY STATISTICS



Return on investment (ROI)
216%

Net present value (NPV)
$14.62M

To better understand the benefits, costs, and risks associated with this investment, Forrester interviewed eight representatives in manufacturing companies with experience using Microsoft HoloLens 2 with Dynamics 365 Guides and Dynamics 365 Remote Assist. For the purposes of this study, Forrester aggregated the interviewees' experiences and combined the results into a single composite organization that is a global manufacturing corporation with an Industry 4.0 focus, generating $18 billion in annual revenues with 120,000 total employees and operating 20 advanced factories. The composite organization for a TEI is a hypothetical organization that intentionally does not reflect any specific customer but encompasses the experiences of all the interviewed customers. The financial model for the TEI is tailored for a company that has the attributes of the composite organization.

Interviewees noted that, prior to using Microsoft HoloLens 2 with mixed reality applications (HoloLens 2 with MRApps), more employees had to travel to solve any problem that on-site teams could not fix, and that their organizations wanted to increase training efficiency and create better documentation that improved manufacturing and training processes.

After the investment in HoloLens 2 with MRApps, the interviewees' organizations enabled users to receive hands-free instruction on the manufacturing line; provided Guides to create virtual instructions that technicians could use to solve problems and complete common repairs that would have otherwise required help from a specialist; and enabled expert technicians to remotely assist on-site work with complex tasks with Remote Assist.

KEY FINDINGS

Quantified benefits. Three-year, risk-adjusted present value (PV) quantified benefits for the composite organization include the following:

- **Improved training productivity of 20% to 24% for the composite organization and reduced training materials costs by 35%.** Microsoft's mixed reality solution enables self-guided instructions and leverages 3D models, simulations, and real-world overlays to ensure factory technicians learn faster, understand content better, and practice machine-specific skills. Technicians also observe and participate in remote demonstrations or are evaluated for certification, saving time and expenses for the composite organization **adding up to more than $2.9 million over three years**.
- **Improved revenues from training effectiveness, worth more than $4.5 million over three years.** With Microsoft's mixed reality solution, the composite organization creates digital twins of sophisticated machines and achieves 24% faster door-to-floor time by Year 3, specifically for new manufacturing technicians. The composite's ability to cut down overall training time compared to previous training processes resulted in increased training productivity, increased time to revenue for existing factories bringing on a steady stream of new hires, and improved product quality.
- **Improved manufacturing operations productivity for skilled technicians by 20%.** Technicians at the composite organization experience productivity benefits, staying head-up and hands-free when accessing HoloLens 2 lenses and Guides software to see and manipulate advanced instructions, schematics, and other vital information overlaid on the real world. The value of Microsoft's mixed reality solution is most impactful for the skilled technicians working with advanced and sophisticated manufacturing equipment. Technicians also use remote collaboration applications, such as Remote Assist, to quickly get support from peers or experts, especially for troubleshooting. This benefit adds up to **more than $2.2 million over three years.**
- **Assured revenue from avoided production downtime, worth more than $2.0 million over three years.** With the introduction of Microsoft's mixed reality solution, the composite organization's expert technicians use remote collaboration applications, such as Remote Assist, to quickly get support from manufacturing subject matter experts (SMEs) for equipment troubleshooting. Faster troubleshooting for unplanned machine downtime enables faster time to revenue for existing factories. Mixed reality technology enables the composite organization to reduce downtime caused by equipment failure or malfunction by 23.5%.
- **Improved field technician productivity by 25%.** Real-time remote collaboration enables "see what I see" assistance from and with manufacturing SMEs to complete work or resolve issues beyond the workers' expertise without

requiring extra trips. Field workers consequently save time, prevent errors and rework, avoid excess trips, and increase their productive capacity, **worth $1.8 million over three years**.

- **Improved manufacturing SME productivity by 30% with remote problem resolution.** Prior to the deployment of Microsoft's HoloLens 2 mixed reality solution, the composite organization's skilled manufacturing and field technicians typically had to request on-site assistance from manufacturing SMEs when they ran into problems with machinery on the production line or in the field. With the introduction of Microsoft's mixed reality solution, expert manufacturing and field technicians use remote collaboration applications, such as Remote Assist, to quickly get support from manufacturing SMEs for equipment troubleshooting and dealing with product issues in the field with experts using mixed reality remote support for critical needs to avoid travel, boost capacity, and address needs more efficiently. Overall, this benefit is worth **more than $2.2 million over three years** for the composite organization**.**
- **Improvement of 14 days in time to revenue for new factories ramping online faster with digital twins and manufacturing layout.** Creating a digital twin of equipment during the factory/line-planning process with HoloLens 2 and Remote Assist ensures that machines will fit and not require engineering change and incur more cost. The ability for up-front planning and laying out the equipment and process flow for production lines allows for faster time to revenue, estimated at a minimum of two weeks adding up **to $3.7 million over three years**.
- **Saved overall traveling expenses by 20% to 50%.** Replacing expert travel with remote expertise and self-guided task worker instruction saves significant travel and incidentals costs, such as flights, cars, hotels, food, and beverage, in addition to labor savings, adding up to **$2.1 million over three years**.

Qualitative benefits. Benefits that provide value for the composite organization but are not quantified for this study include:

- **Furthered sustainability goals.** Sustainability improvements and cost savings reduce training material waste and emissions associated with travel.
- **Hands-free and remote training.** Providing an immersive training experience allows employees the ability to train wherever, whenever in a head-up, hands-free environment.
- **Improved quality with enhanced employee experience.** Holographic work instruction through Dynamics 365 Guides accessible via HoloLens 2 improves employees' productivity with 3D, step-by-step, holographic step cards that reduce errors, increase efficiency, ensure that procedure is followed safely, and overall improve the quality of work.
- **Attract, hire, and retain higher-quality employees.** Leveraging HoloLens 2 and Dynamics 365 Guides and Remote Assist helps differentiate a company recruitment strategy by using the latest and greatest technology, leading to cost saving in acquiring and retaining highly talented employees.
- **Protected health and safety.** According to interviewees, MR instructions helped employees get through repetitive tasks more quickly — and could protect life and health. Not following procedures exactly as intended could lead to dangerous scenarios in a manufacturing context. HoloLens 2 with Guides enabled technicians to follow instructions that provided guidance and training while doing their work, ensuring procedures are followed safely.

- **Improved compliance.** Process guides helped technicians using HoloLens 2 follow the steps properly, helping meet compliance standards.

Costs. Three-year, risk-adjusted PV costs for the composite organization include:

- **HoloLens 2 device costs.** This cost is for the purchase of devices retailing at $3,500 each, plus repair and device management over three years.
- **Guides and Remote Assist subscription and consumption costs.** This cost is to enable instructions, visualization, and remote collaboration capabilities for up to 800 active, licensed users by Year 3. This is based on a realistic deployment of HoloLens 2 devices where five licensed users share each device.
- **Planning, implementation, and management labor costs.** The team included an innovation leader, technical project managers, 3D designers, developers, and IT operations (ITOps) aided by test users and a systems integrator (SI) to conduct MR training and coordinate planning. For the composite organization, this is based on an innovation team of 10 FTEs, which scales depending on the organization's size.
- **Training costs** for up to 800 annual mixed reality users.

The representative interviews and financial analysis found that a composite organization experiences benefits of $21.39 million over three years versus costs of $6.77 million, adding up to a net present value (NPV) of $14.62 million and an ROI of 216%.

"We have a digital initiative for Industry 4.0. There's an industry trend for that. And so, I see new technology and being innovative is key to our survival as a company. And there are four main technologies right now on the roadmap and XR is one of them."

— Senior manager, engineer services support process systems development, transportation manufacturing

ROI
216%

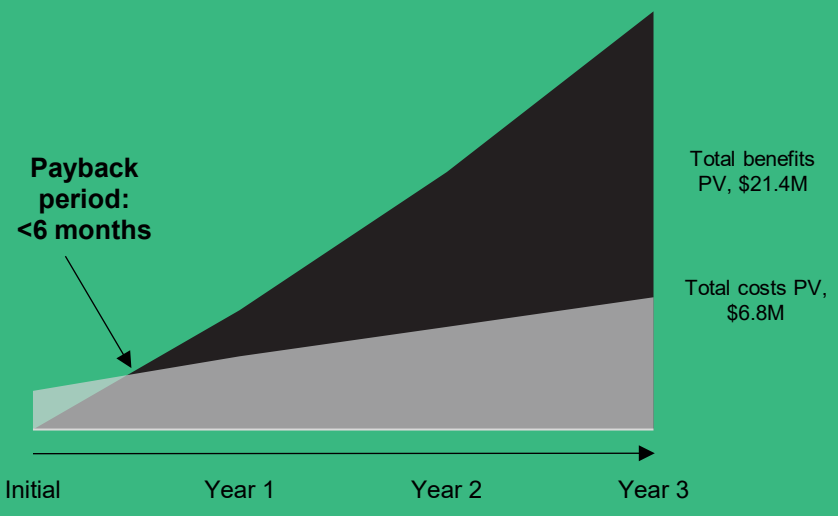
BENEFITS PV
$21.39M

NPV
$14.62M

PAYBACK
<6 months

Benefits (Three-Year)

Financial Summary



TEI FRAMEWORK AND METHODOLOGY

From the information provided in the interviews, Forrester constructed a Total Economic Impact™ framework for those organizations considering an investment HoloLens 2 with MRApps.

The objective of the framework is to identify the cost, benefit, flexibility, and risk factors that affect the investment decision. Forrester took a multistep approach to evaluate the impact that HoloLens 2 with MRApps can have on an organization.

DUE DILIGENCE

Interviewed Microsoft stakeholders and Forrester analysts to gather data relative to the HoloLens 2 with MRApps.

CUSTOMER INTERVIEWS AND SURVEY

Interviewed eight decision-makers and surveyed 312 decision-makers at organizations using the HoloLens 2 with MRApps to obtain data with respect to costs, benefits, and risks.

COMPOSITE ORGANIZATION

The composite organization for a TEI is a hypothetical organization that intentionally does not reflect any specific customer but encompasses the experiences of all the interviewed customers. The financial model for the TEI is tailored for a company that has the attributes of the composite organization.

FINANCIAL MODEL FRAMEWORK

Constructed a financial model representative of the interviews and survey using the TEI methodology and risk-adjusted the financial model based on issues and concerns of the interviewed organizations.

CASE STUDY

Employed four fundamental elements of TEI in modeling the investment impact: benefits, costs, flexibility, and risks. Given the increasing sophistication of ROI analyses related to IT investments, Forrester's TEI methodology provides a complete picture of the total economic impact of purchase decisions. Please see Appendix A for additional information on the TEI methodology.

DISCLOSURES

Readers should be aware of the following:

This study is commissioned by Microsoft and delivered by Forrester Consulting. It is not meant to be used as a competitive analysis.

Forrester makes no assumptions as to the potential ROI that other organizations will receive. Forrester strongly advises that readers use their own estimates within the framework provided in the study to determine the appropriateness of an investment in HoloLens 2 with MRApps.

Microsoft reviewed and provided feedback to Forrester, but Forrester maintains editorial control over the study and its findings and does not accept changes to the study that contradict Forrester's findings or obscure the meaning of the study.

Microsoft provided the customer names for the interviews but did not participate in the interviews.

The Microsoft HoloLens 2 with Mixed Reality Applications Customer Journey

Drivers leading to the HoloLens 2 with MRApps investment

Interviews

Role	Industry	Revenue	Employees	Number Of HL 2 Devices
Director of augmented engineering services	Pharmaceuticals manufacturing	>$35 billion	>300,000	>500
Department manager, field tech services	Automotive manufacturing	>$20 billion	>125,000	>400
Lead solutions engineer, intelligent automation and AIOps infrastructure services	Power management manufacturing	>$15 billion	>175,000	>250
Senior manager, engineer services support and process systems development	Transportation manufacturing	>$25 billion	>225,000	50
Senior training program manager	Semiconductor supplier	>$8 billion	>800,000	500
Engineering project lead	Semiconductor manufacturing	>$10 billion	>90,000	>200
Tech fellow	Aeronautics manufacturing	>$15 billion	>125,000	>250
Senior advanced mechanical design engineer	Manufacturing conglomerate	>$35 billion	>350,000	1

KEY CHALLENGES

The interviewees noted how their organizations struggled with common challenges, including the following:

- **Travel to provide assistance in solving complex problems that on-site teams could not fix.** Interviewees noted that prior to investing in HoloLens 2 with MRApps, every time there was a complex issue that could not be resolved by on-site technicians, an expert technician or SME would need to travel to solve the problem and provide assistance in person. The department manager in field tech services at an automotive manufacturing organization explained, “Our interest was, if we can use technology and see what the technician sees, in a certain percentage of those cases, we can resolve the issue without actually physically going there.”

“We’re teaching people how to maintain the tools and we’re teaching them somewhat in the classroom and somewhat on the tools. So, in the classroom, it’s PowerPoint like it is everywhere. And he’s like, maybe we need to make that better.”

Engineering project lead, semiconductor manufacturing

- **Training technicians to complete complex tasks and repairs.** Training technicians to complete complex tasks or repairs is a long process that is essential for manufacturing

organizations. Furthermore, there is a retirement crisis in industrial verticals in which people in their 50s and 60s are retiring and organizations must digitize their expertise and then quickly onboard new employees. Interviewees noted that using HoloLens 2 with Guides in the training process created muscle memory and helped trainees learn the process faster. The lead solutions engineer of intelligent automations and AIOps infrastructure services at a powerplant manufacturing organization said: "Trainees can use the HoloLens 2 like a crutch. So, maybe they forgot the second step in the process. They can use HoloLens 2 to be like, 'Okay, this is exactly what I'm doing.' And then they kind of go back and forth between it and it creates that muscle memory for them, and they do a really good job in terms of catching on quicker."

- **Training processes were only documented in Excel with static pictures.** Prior to HoloLens 2 with MRApps, some manufacturing training processes were drafted in Excel and accompanied with static pictures. The senior advanced mechanical design engineer from a manufacturing conglomerate said: "Actually, in the previous state, we were using Excel from Microsoft. The content creator was doing the job of drafting the document. In that scenario, we take one expert from the manufacturing line and he or she will start to write the document, take some pictures, and all the expertise will be written with the risk of the bias, obviously, of that expert."

"HoloLens 2 allows you to see through the eyes of another person … So that's why we decided to use the telepresence device only for gamba recordings and HoloLens 2 for the actual production phase of the product."

Senior advanced mechanical design engineer, manufacturing conglomerate

SOLUTION REQUIREMENTS

- **Enable expert technicians to remotely assist on-site workers with complex tasks.** Using HoloLens 2 with MRApps enabled technicians to capture the manufacturing process with all the necessary details and gain an understanding of the whole layout. A senior advanced mechanical design engineer at a manufacturing organization explained, "It was easier for us to catch the manufacturing processes through HoloLens 2, understanding the whole layout of the product instead of an external video that [does not allow you to] capture all the details."
- **Create guides that technicians can use to solve problems and complete repairs that they would not have been able to otherwise.** One of the key objectives that interviewees mentioned was using HoloLens 2 with MRApps to create a repository of guides with Dynamics 365 Guides to solve certain problems or complete certain repairs that are more complex than others. A department manager in field tech services at an automotive manufacturing organization explained, "The idea is if [we] have a less experienced technician [who] maybe didn't have a chance to go to a training session or [if] we have certain repairs [that are] more difficult than others, we can quickly create a guide and an individual user can use it to complete repairs."
- **Enable the user to receive hands-free instruction and is intuitive and reliable to use on the manufacturing line for extended periods of time.** A senior manager of engineering services support and process

systems development from a transportation manufacturing organization explains, "[HoloLens2 is] not really complicated to use … [and it's] fairly self-intuitive how to use it."

COMPOSITE ORGANIZATION

Based on the interviews, Forrester constructed a TEI framework, a composite company, and an ROI analysis that illustrates the areas financially affected. The composite organization is representative of the eight interviewees at manufacturing companies, and it is used to present the aggregate financial analysis in the next section. The composite organization has the following characteristics:

Key assumptions

- **$18 billion revenue**
- **20 factories**
- **120,000 total employees**
- **1,000 field technicians**
- **60,000 factory employees**
- **6,000 skilled manufacturing technicians**

Description of composite. The global manufacturing corporation generates $18 billion in revenues and has 120,000 total employees, and 1,000 field technicians. It also operates 20 factories with approximately 60,000 factory employees, including 6,000 skilled technicians.

Deployment characteristics. The composite organization enhances the training of technicians, enables field troubleshooting, and brings new factories online, among several other value-creating activities and tasks. Due to the relative novelty, training, and expense of the HoloLens 2 for MRApps solution, the composite organization has a deployment ramp for rolling out the technology:

- An optimal configuration of HoloLens 2 devices comprises of 1,050 devices deployed each year. This corresponds with licensing 7,953 active users each year (with approximately five users sharing one HoloLens device). This configuration would enable the composite to have 100% utilization of the MR technology for each year.
- The *modeled* configuration of HoloLens 2 devices for this study is 100 devices deployed in Year 1, 130 in Year 2, and 160 in Year 3. This corresponds with licensing 500 active users in Year 1, 680 in Year 2, and 790 in Year 3 (with approximately five users sharing one HoloLens device). This practical configuration enables the composite to have approximately 15% utilization of the MR technology by Year 3 for most uses (row R11), including manufacturing operations. For training of new factory and skilled technicians, there would be sufficient HoloLens 2 units available to be shared for 100% utilization by Year 3 (row R12).

Key modeling assumptions. To quantify the economic and productivity benefits that the composite organization incurs with the deployment of the HoloLens 2 MRApps solution, Forrester uses the following set of assumptions in the financial model (that are shown and calculated in the accompanying reference tables R and S):

- The composite has 20 fully operational factories coming in Year 1. Each factory is assumed to have 10 production lines; each line has 10 pieces of equipment, six of which require manual operation with expert technicians.
- The composite increases factory capacity by five additional lines per year in Years 1, 2, and 3, or half of a full factory's manufacturing capacity each year.

Detailed Composite Characteristics					
Ref.	**Metric**	**Source**	**Year 1**	**Year 2**	**Year 3**
R1	**Fully operational factories**	**Composite**	**20.0**	**20.5**	**21.0**
R2	Shifts per week	Composite	3.0	3.0	3.0
R3	Weeks of production time per year	Composite	52	52	52
R4	Length of each shift (hours per week)	Composite	32.0	32.0	32.0
R5	Annual hours of factory operation	R2*R3*R4	4,992	4,992	4,992
R6	Production lines per factory	Composite	10	10	10
R7	Manually operated machine stations per production line	Composite	6	6	6
R8	Field service locations	Composite	50	52	54
	HoloLens 2 devices deployment (including compatible licensing of Guides and Remote Assist MR software)				
R9	HL2 devices deployed — optimal configuration	Composite	1,050	1,050	1,050
R10	HL2 devices deployed — actual configuration	Composite	100	130	160
R11	Deployment ramp of Microsoft's HL2 MR solution — for operations	R10/R9	10%	12%	15%
R12	Deployment ramp of Microsoft's HL2 MR solution — for training	R10/$R10_{Y3}$	63%	81%	100%
R13	Licensed RA and Guides users	Composite	500	680	790

- Each factory operates three shifts of 32 hours each per line (enabling planned downtime for shift changes and maintenance, etc.). Each line and factory operate for all 52 weeks of the year.
- The composite employs 120,000 people overall with 60,000 factory employees in Year 1. Based on the number of lines, shifts, and manual machinery per line, there are 6,000 skilled factory technicians required in Year 1.
- Factory production generates 80% of the composite's $18 billion in revenue, or $14.4 billion in Year 1. Thus, each factory generates $720 million in revenue in Year 1, which increases with productivity and efficiency improvements.

Detailed Composite Revenue Metrics

Ref.	Metric	Source	Year 1	Year 2	Year 3
S1	**Total employees**	**Composite**	**120,000**	**123,500**	**127,100**
S2	Factory employees	Composite	60,000	61,800	63,600
S3	Skilled factory technicians	R1*R2*R6*10	6,000	6,150	6,300
S4	Field technicians	R8*20	1,000	1,040	1,080
S5	Manufacturing SMEs	R7*8	48	48	48
S6	**Annual revenue**	**Composite**	**$18,000,000,000**	**$18,720,000,000**	**$19,468,800,000**
S7	Revenue from factory production	S6*80%	$14,400,000,000	$14,976,000,000	$15,575,040,000
S8	Revenue per factory	S7/R1	$720,000,000	$730,536,585	$741,668,571
S9	Revenue per factory per hour	S8/R4	$144,231	$146,341	$148,571
S10	Revenue per production line per hour	S9/R5	$14,423	$14,634	$14,857
S11	Revenue per factory employee	S7/S2	$240,000	$242,330	$246,051
S12	Revenue per factory employee per hour	S10/R3/R4	$144	$146	$148
S13	Revenue per skilled factory technician	S7/S3	$2,400,000	$2,435,122	$2,472,229
S14	Revenue per skilled factory technician per hour	S12/R3/R4	$1,442	$1,463	$1,486

Analysis Of Benefits

Quantified benefit data as applied to the composite

Total Benefits						
Ref.	**Benefit**	**Year 1**	**Year 2**	**Year 3**	**Total**	**Present Value**
Atr	Training productivity improvement and materials cost savings	$975,010	$1,170,233	$1,404,310	$3,549,552	$2,908,586
Btr	Improved revenues from training effectiveness	$1,302,408	$1,794,502	$2,442,289	$5,539,198	$4,501,994
Ctr	Manufacturing operations productivity improvement	$661,939	$868,465	$1,181,561	$2,711,965	$2,207,227
Dtr	Revenue assurance from avoided production downtime	$628,919	$802,329	$1,077,040	$2,508,289	$2,044,023
Etr	Field technician productivity improvement	$537,030	$693,127	$929,475	$2,159,632	$1,759,369
Ftr	Manufacturing SME productivity improvement	$658,920	$891,072	$1,152,192	$2,702,184	$2,201,100
Gtr	Improved time to revenue for new factories ramping online	$1,171,564	$1,490,328	$1,836,326	$4,498,218	$3,676,393
Htr	Overall travel and incidentals savings	$786,996	$836,249	$907,310	$2,530,555	$2,088,241
	Total benefits (risk-adjusted)	$6,722,786	$8,546,305	$10,930,503	$26,199,594	$21,386,933

TRAINING PRODUCTIVITY IMPROVEMENT AND MATERIALS COST SAVINGS

Evidence and data. Prior to the deployment of Microsoft's HoloLens 2 mixed reality (MR) solution, interviewees' organizations trained technicians — especially skilled manufacturing technicians — with traditional approaches, such as in-class PowerPoint presentations, training videos, and on-hands instruction on expensive and limited machines. Most interviewees cited how Microsoft's MR solution enabled self-guided mixed reality instructions, leveraging 3D models, simulations, and real-world overlays to enable factory technicians to learn faster, understand content better, and practice machine-specific skills. Technicians could also observe and participate in remote demonstrations and be evaluated for certification, saving time and expense. Some interviewees described how creating digital twins of these sophisticated machines enabled them to reduce virtual, hands-on training without disrupting production time. It should be noted that training of field technicians (an important cohort, but not critical to manufacturing operations) is not included here.

Deploying HoloLens 2 with MRApps **improves training productivity by 24%** in Year 3

As the expenses associated with developing training materials for MR technology are included in the Cost section, the corresponding cost savings of not having to produce traditional training materials is the second component of this benefit.

This specific training benefit speaks to the amount of training effort or cost that was reduced when the interviewees' organizations deployed Microsoft's MR solution. The key metric described by most interviewees was the reduced overall training time for

skilled manufacturing technicians, also referred to as the door-to-floor reduction in time compared to their prior states. Interviewees shared many examples of training productivity improvement and materials cost savings benefits, along with data insights, including the following:

- The senior training program manager at a semiconductor supplier stated: "Existing engineers probably go to one training class a year, and new hires are probably going to go to two more. It depends. Because of the way our service model is, our customers know they have a certified engineer working on the tools. If we hire somebody whilst he can go and he can shadow in the field, he can't truly do his job until he's certified on at least one tool."
- The senior manager, engineering services support and process systems development at a transportation manufacturing firm provided their perspective: "So, a training could take 20 days — it's been reduced to 15 days. And also, to get the person to a professional or to a certified trainer, usually that process takes up to 40 to 45 days … and now we're seeing that reduced by another seven days."
- The engineering project lead for a semiconductor manufacturer spoke about their goals for the MR technology for training, noting, "Our goal was from our baseline that we really wanted to achieve a 50% improvement in training and a 50% reduction in trainer burden."
- Interviewees noted that the reduction in overall training time for manufacturing technicians ranged from 19.4% to 30%. The weighted average of this same metric from the survey yielded 19.9%. Blending these data points results in an average of 23.5%.
- Interviewees provided ranges for time required to train new technicians both before and after the deployment of MR technology. Predictably this varied by organization and was largely based on the sophistication of their equipment. It ranged from 62 days before to 50 days after; six months down to four months; and aspired to cut six to nine months of training by 50%.

"They have their time with the trainer and they're able to kind of use the HoloLens like a crutch. So, maybe they forgot the second step of the process. They can use the HoloLens to be like, 'OK, this is exactly what I'm doing.' And then they kind of go back and forth between it and it creates that muscle memory for them, and they do a really good job in terms of catching on quicker."

Lead solution engineer, power management manufacturing

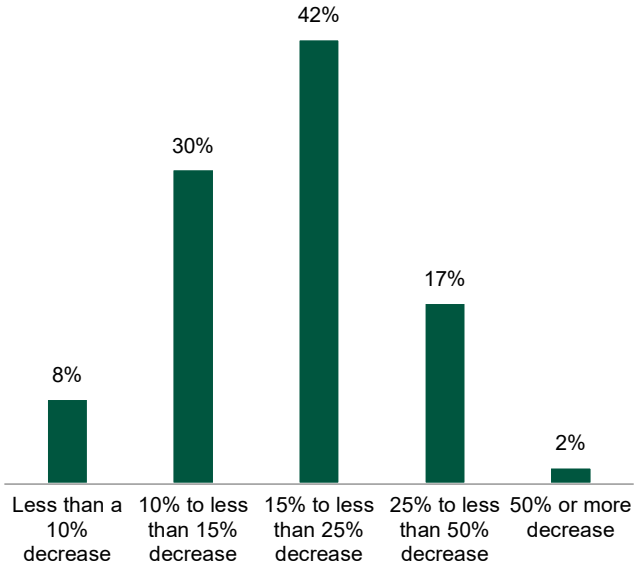
Deploying HoloLens 2 with MRApps **reduces training materials expenses by 35%** in Year 3

Modeling and assumptions. The focus of this benefit is training productivity improvement enabled with Microsoft's MR solution with the key metric being the reduction in training time for skilled manufacturing technicians — both new hires, and existing technicians being trained on new equipment. Also included is the saving in materials costs compared to the prior state of training. Forrester modeled the

impact for the composite organization assuming the following:

- The composite organization needs 150 new skilled manufacturing technicians per year for factory expansion. However, with an assumed 5.0% attrition rate, this implies that 445 new technicians need to be hired and trained in Year 1. Correspondingly, 5,850 of the existing manufacturing technicians need incremental training in Year 1.
- Forrester conservatively models that the full impact of deploying Microsoft's MR solution is 20% in Year 1, 22% in Year 2, and 24% in Year 3. It is worth noting and clarifying the difference between this holistic metric compared to a similar metric identified in a previous Microsoft MR study, titled, "The Total Economic Impact™ Of Mixed Reality Using Microsoft HoloLens 2." For the current study, we focus on the total door-to-floor training time reduction, including the time expended to learn HoloLens 2 and the applications. In the prior study, there was a 75% reduction in training time *for specific training components* that were replaced by HoloLens 2.[2] Even with a 20% to 24% reduction in door-to-floor training time for the current study, the total number of training hours saved are significantly higher than the prior study.
- Given the Industry 4.0 focus for the composite that is manufacturing leading edge products with complex machinery, Forrester models eight weeks of training at 25 hours per week for new technicians, which is 200 hours for the first year before the use of MR technology. For existing technicians, a more modest 10 hours of training per year is assumed.
- The fully burdened annual salary for the average manufacturing technician is $54,000, even for a global enterprise with varying pay scales due to the sophistication of these technicians. This computes to an average hourly rate of $26.
- For the training of manufacturing technicians, it is assumed that enough HoloLens 2 devices are available to adequately train the new technicians for the required hours, as well as the existing technicians for their relatively lower number of training hours. Thus, the deployment ramp for the Microsoft MR technology is assumed in row A9, which reflects the training ramp.
- The cost of training materials is a weighted average of $1,000 per new trainee and $250 per existing trainee.
- Deploying MR technology saves the composite organization 35% on traditional training materials expenses.

"Using your best estimate, what would the potential time savings be from training efficiencies related to an investment in MR headsets?"



Base: 306 decision-makers working as operations professionals, frontline workers, or training/teaching/research employees in the architecture and engineering construction (AEC), education, healthcare, or manufacturing industries who use mixed reality headsets for their organizations, which have at least 1,000 employees; varies from total base of 312 due to some respondents opting to not respond to this question.
Source: A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2023

Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- Mixed reality's ability to supplement or replace training and its associated benefit will depend on the specific users, tasks, and functions.
- Training savings hinge on the upfront investment of building relevant and high-quality MR curricula.
- Savings recaptured will depend upon the number of users reached and their average labor cost.

Results. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $2.91 million.

Training Productivity Improvement And Materials Cost Savings

Ref.	Metric	Source	Year 1	Year 2	Year 3
A1	Existing skilled factory technicians	S3-S3*2.5%	5,850	6,000	6,140
A2	Training hours per existing skilled factory technician	Interviews	10	10	10
A3	New skilled factory technicians hired	S3-$S3_{PY}$+$S3_{PY}$*5%	443	450	458
A4	Training hours per new skilled factory technician	Interviews	200	200	200
A5	Total technician training hours before Microsoft HL2 MR solution deployed	A1*A2+A3*A4	147,100	150,000	153,000
A6	Reduction in training time with Microsoft HL2 MR solution	Interviews and survey	20%	22%	24%
A7	Total technician training hours saved with Microsoft HL2 MR solution deployed	A5*A6	29,420	33,000	36,720
A8	Fully burdened hourly salary of average manufacturing technician	TEI standard	$26	$26	$26
A9	Deployment ramp of Microsoft HL2 MR solution - for training	R12	63%	81%	100%
A10	Subtotal: Training productivity improvement	A7*A8*A9	$481,900	$694,980	$954,720
A11	Annual trainees	A1+A3	6,293	6,450	6,598
A12	Cost of training materials and consumables per trainee	Interviews	$302	$302	$302
A13	Avoided training materials expenses with Microsoft HL2 MR solution	Survey	35%	35%	35%
A14	Subtotal: Training materials cost savings due to Microsoft HL2 MR solution	A11*A12*A13	$665,170	$681,765	$697,409
At	Training productivity improvement and materials cost savings	A10+A14	$1,147,070	$1,376,745	$1,652,129
	Risk adjustment	↓15%			
Atr	Training productivity improvement and materials cost savings (risk-adjusted)		$975,010	$1,170,233	$1,404,310
	Three-year total: $3,549,552			**Three-year present value: $2,908,586**	

IMPROVED REVENUES FROM TRAINING EFFECTIVENESS

Evidence and data. As noted in the previous benefit, prior to the deployment of Microsoft's HoloLens 2 MR solution, interviewees' organizations trained skilled manufacturing technicians with traditional approaches. With Microsoft's MR solution, several interviewees described how creating digital twins of these sophisticated machines enabled them to achieve faster door-to-floor time specifically for new technicians basically, cutting down overall training time compared to how training was conducted previously. Doing so resulted in not only improved training productivity that we already discussed, but also improved time to revenue for existing factories bringing on a steady stream of new hires.

In addition to the faster ramp for new trainees, interviewees emphasized the improvement in the quality of training with Microsoft's MR solution. Hands-on training with a digital twin would be akin to flight simulator training for a pilot. Some interviewees described this improvement in quality in terms of reduced scrap materials, anecdotal observations, and aspirational goals. This improved quality benefit applied to all skilled technicians delivering higher-quality products (improved yield) by being trained on the Microsoft MR solution.

This benefit discusses the amount of training effort or cost that was reduced when the interviewees' organizations deployed Microsoft's MR solution. The key metric described by most interviewees was the reduced overall training time for these skilled manufacturing technicians or the door-to-floor reduction in time compared to the prior state. As the expenses associated with developing training materials for MR technology are included in the cost section, the corresponding cost savings of not having to produce traditional training materials is the second component of this benefit. Interviewees shared examples of door-to-floor productivity improvement, along with data insights, including the following:

- The director of augmented engineering services at a pharmaceutical manufacturer explained: "So then you take them to the floor and now they see the exact same instructions and they have the exact same media referencing the instruction just as they had in training. The difference is with using the HoloLens 2 is that you don't have to have the digital twin now because you have the real machine."
- The engineering project lead for a semiconductor manufacturer further expanded on their goals for Microsoft's MR technology, stating, "Our goal is a reduction in training time — reduction in trainer burden and a 50% improvement in training quality."
- The lead solution engineer of intelligent automation and AIOps infrastructure services provided their perspective, noting "I think at we see probably a 5% reduction in scrap which I think that's pretty significant."
- Interviewees spoke about the potential benefits of higher production quality driven by improved training, but there was only a single quantitative data point of a 5% reduction in scrap materials.

Modeling and assumptions. The focus of this benefit is faster time to revenue enabled with Microsoft's MR solution, with the key metric being the reduction in door-to-floor training time for newly hired skilled manufacturing technicians. The second component of this benefit is the improvement in revenues due to the production of higher-quality products as a function of higher-quality training with

24% reduction in door-to-floor time for new technicians trained with HoloLens 2 with MRApps by Year 3

MR technology. Forrester modeled the impact for the composite organization assuming the following:

- The composite organization has 295 new technicians that require training in Year 1.
- Forrester models eight weeks of training at 25 hours per week for new technicians, which is 200 hours for the first year before the use of MR technology.
- Based on the analysis of various data points for benefit A, Forrester conservatively models that the full impact of deploying the Microsoft's MR solution results in a door-to-floor training time reduction of 20% in Year 1, 22% in Year 2, and 24%.
- The revenue generated per skilled technician, based on the composite characteristics, is $1,442 per hour in Year 1 (improving with productivity and learnings). It is worth noting that the revenue generated per average factory employee is $144 per hour. The reality is that the composite organization would not be able to meet its revenue targets without the key role played by the skilled manufacturing technicians. To be conservative, Forrester applies a 50% productivity adjustment.
- For training manufacturing technicians, it is assumed that a sufficient number of HoloLens 2 devices is available to adequately train the new technicians for the required hours. Thus, the deployment ramp for the Microsoft MR technology is assumed in row B7, which reflects the training ramp.
- For the second component of this benefit — improved quality of production — it is assumed that the benefits of higher-quality training enabled with Microsoft's MR solutions accrues to all skilled technicians.
- To be conservative, Forrester assumes a 2.5% improvement in production quality enabled from the Microsoft MR solution.
- The annual revenue per factory employee for the composite is computed to be $240,000.
- To determine the net business impact for the composite, the revenue benefit is converted into operating profits. The model assumes an operating margin of 15% for a higher-end complex manufacturer.

Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- Variations in percentage improvement in production quality across different manufacturing organizations.
- Differences in annual revenue per factory employees by organization and region.
- Variations in operating margins across different types of manufacturing businesses.

"We build out digital twins, a replica at scale of a piece of equipment. The trainees are introduced to HoloLens's understanding of what the equipment is. I'm a huge proponent of the what and why prior to going into something."

Director of augmented engineering services, pharmaceuticals manufacturing

At least 2.5% improvement in production quality enabled with the Microsoft MR solution

Results. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $4.5 million.

Improved Revenues From Training Effectiveness

Ref.	Metric	Source	Year 1	Year 2	Year 3
B1	New skilled factory technicians hired	A3	443	450	458
B2	Training hours per new skilled factory technician	A4	200	200	200
B3	Reduction in training time with Microsoft HL2 MR solution	A6	20%	22%	24%
B4	Additional production hours for new technicians from faster door-to-floor	B1*B2*B3	17,720	19,800	21,984
B5	Revenue per skilled factory technician per hour	S14	$1,442	$1,463	$1,486
B6	Adjusted revenue contribution for skilled factory technicians	TEI standard	40%	40%	40%
B7	Deployment ramp of Microsoft HL2 MR solution — for training	R12	63%	81%	100%
B8	Subtotal: Faster time to revenue for new technicians	B4*B5*B6*B7	$6,439,164	$9,385,438	$13,067,290
B9	Annual trainees	A11	6,293	6,450	6,598
B10	Improved quality due to more effective training with Microsoft HL2 MR solution	Interviews	2.5%	2.5%	2.5%
B11	Annual revenue per factory employee	S11	$240,000	$242,330	$246,051
B12	Deployment ramp of Microsoft HL2 MR solution — for operations	R11	10%	12%	15%
B13	Subtotal: Improved revenue from higher quality based on more effective training	B9*B10*B11*B12	$3,775,800	$4,689,086	$6,087,917
B14	Operating margin	Composite	15%	15%	15%
Bt	Improved revenues from training effectiveness	(B8+B13)*B14	$1,532,245	$2,111,178	$2,873,281
	Risk adjustment	↓15%			
Btr	Improved revenues from training effectiveness (risk-adjusted)		$1,302,408	$1,794,502	$2,442,289
	Three-year total: $5,539,198			**Three-year present value: $4,501,994**	

MANUFACTURING OPERATIONS PRODUCTIVITY IMPROVEMENT

Evidence and data. Prior to the deployment of Microsoft's HoloLens 2 MR solution, manufacturing technicians typically had to refer to instruction manuals and reference charts during their day-to-day tasks of operating machines during production time. Most interviewees discussed the productivity benefits enjoyed by these technicians when having access to HoloLens 2 lenses and Guides software to see and manipulate advanced instructions, schematics, and HoloLens vital information that is overlaid on the real world, while remaining head-up and hands-free. Again, the value of Microsoft's MR solution was most impactful for the skilled technicians working with advanced and sophisticated manufacturing equipment, who were higher-compensated workers compared to regular factory workers.

Interviewees noted that technicians also used remote collaboration applications, such as Remote Assist, to quickly get support from peers or experts, especially for troubleshooting. While there was an aspect of easier access to subject matter experts (SMEs) on sophisticated manufacturing equipment for these skilled technicians, the bulk of that benefit accrued to the manufacturing SMEs and is modeled in benefit F.

This benefit addresses the manufacturing productivity improvement for skilled technicians deploying Microsoft's MR solution. The key metric extracted from the survey was the increase in task efficiency for these skilled manufacturing technicians, as it applies to tasks that could be enhanced with MR technology.

The director of augmented engineering services working in pharmaceuticals manufacturing said: "If you think about it, you're investing in the operator. You give them the information they need when they need it. You're giving them the ability to call for help even if they still have questions about whatever that task is. It's been extremely beneficial."

20% increase in task efficiency for skilled technicians during manufacturing operations by utilizing HoloLens 2 with MRApps

"You can appreciate the potential cost savings there is by making the right decision instead of the wrong decision when it comes to manufacturing that. They're now all over the possibilities that they have now that they can build anything they want virtually."

Engineering project lead, semiconductor manufacturing

Modeling and assumptions. The focus of this benefit is manufacturing productivity improvement enabled with Microsoft's MR solution with the key metric being increased task efficiency for skilled manufacturing technicians for ongoing operations enabled with MR technology. This benefit does not attempt to capture any productivity benefit for faster resolution of downtime or troubleshooting incidents, as that value is calculated in benefit D. Forrester modeled the impact for the composite organization assuming the following:

- The composite organization starts with 6,000 skilled technicians in Year 1 and adds a net of 150 new technicians each year based on the rollout of additional manufacturing lines.
- For manufacturing operations, it is assumed that the composite does not have sufficient HoloLens 2 devices available to adequately equip the number of technicians even when shared by five technicians, as assumed. Thus, the deployment

ramp for the Microsoft MR technology assumed in row C2 is the much more modest operations ramp.

- The percentage of tasks that are enabled by MR technology for skilled technicians varies by the type of equipment and the products manufactured. The composite experiences a range of 15% to 17% from Year 1 to Year 3.
- The primary metric for this benefit, task efficiency improvement with MR for manufacturing technicians, is 20%.
- Consistent with benefit A, the fully burdened annual salary for the average manufacturing technician is $54,000, which computes to an average hourly rate of $26.

Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- Differences in numbers of skilled technicians across organizations.
- Variations in adoption of MR technology across organizations.
- Varying levels of efficiency gains in tasks by manufacturing technicians across different organizations.

Results. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $2.21 million.

Manufacturing Operations Productivity Improvement

Ref.	Metric	Source	Year 1	Year 2	Year 3
C1	Skilled factory technicians	S3	6,000	6,150	6,300
C2	Deployment ramp of Microsoft HL2 MR solution — for operations	R11	10%	12%	15%
C3	Number of technicians with access to HL2 MR solution	C1*C2	600	738	945
C4	Percentage of tasks enhanced with MR	Interviews	15%	16%	17%
C5	Increase in task efficiency with MR	Survey	20%	20%	20%
C6	Working hours per skilled factory technician	R3*R4	1,664	1,664	1,664
C7	Fully burdened hourly salary of average manufacturing technician	A8	$26	$26	$26
Ct	Manufacturing operations productivity improvement	C3*C4*C5*C6*C7	$778,752	$1,021,723	$1,390,072
	Risk adjustment	↓15%			
Ctr	Manufacturing operations productivity improvement (risk-adjusted)		$661,939	$868,465	$1,181,561
	Three-year total: $2,711,965			**Three-year present value: $2,207,227**	

REVENUE ASSURANCE FROM AVOIDED PRODUCTION DOWNTIME

Evidence and data. Irrespective of products produced or manufacturing technology, interviewees noted that the process of manufacturing complex products with sophisticated equipment was fraught with risks of downtime. Planned downtime generally refers to time scheduled for equipment maintenance and process upgrades, etc. Unplanned downtime could be especially pernicious and potentially crippling for the interviewees' organizations. Sophisticated machinery could fail, break down, or sometimes need to be recalibrated during operational runtime. This was above and beyond any power failure or network performance degradation. Before the adoption of Microsoft's HoloLens 2 MR solution, when interviewees' organizations experienced equipment-related downtime, the manufacturing SME on the machine (an in-house expert) needed to be called and — more than 50% of the time — had to come in to evaluate the situation. The SME would then have to get on the phone with an expert from the vendor, who produced the specific equipment and diagnose the problem. In the most extreme of cases, the vendor's expert might have to travel in or the equipment would have to be swapped out. Needless to say, countless hours could be spent merely diagnosing the root cause of the problem.

With the introduction of Microsoft's MR solution, expert technicians were able to use remote collaboration applications, such as Remote Assist, to quickly get support from manufacturing SMEs for equipment troubleshooting. Faster troubleshooting for nonmaintenance machine downtime enabled faster time to revenue for existing factories. Clearly, MR technology could not avoid or fix the problem, but it enabled the interviewees' organizations to communicate efficiently and cost-effectively to get the issue resolved.

"I would say on average prior to HoloLens two and half to three days per incident versus how I can connect at any given time from any given place and potentially solve this within 30 minutes to an hour."

Senior manager, engineer services support process systems development, transportation manufacturing

This benefit speaks to the faster troubleshooting for nonmaintenance machine downtime resulting in faster back to production time when the interviewees' organizations deployed Microsoft's MR solution. The key metric described by most interviewees was the reduced downtime for factory equipment compared to the prior state. Interviewees shared examples of faster back to production from equipment troubleshooting, including the following:

- The director of augmented engineering services at a pharmaceutical manufacturer explained: "I would easily say [equipment breaks] three to four times per eight-hour shift per line that's running. These lines are so finicky, and when you're dealing with the variables of components and if a component changes by one millimeter, it could impact the flow of the line."

23.5% reduction in downtime caused by manufacturing equipment issues resolved with remote SME intervention using HoloLens 2 with Remote Assist

- The engineering project lead for a semiconductor manufacturer spoke about their goals for the MR technology for training as: “I would say [for] one vendor or manufacturer [there is a critical breakdown] once or twice a year because the technology we have been running is an older one … that would be much higher when you’re running a new technology and you’ve got new equipment that you’re still learning.”
- The senior manager, engineering services support and process systems development at a transportation manufacturing firm provided their perspective, noting “It’s not just because you can’t travel but it’s because a plant is a 14- to 16-hour flight away makes travel very hard.”
- The lead solution engineer of intelligent automation and AIOps infrastructure services provided their perspective, stating, “We have anywhere from three to five of those trips that are being avoided every month.”
- Interviewees provided estimates for the frequency of downtime incidents in a factory production line, largely varying by the size of the organization and the complexity of the manufacturing process.

Modeling and assumptions. This benefit focuses on the faster back-to-production timeframe for troubleshooting of manufacturing operations enabled with Microsoft’s MR solution. The key metric is the reduction in factory downtime caused by equipment malfunction or failure. Forrester modeled the impact for the composite organization assuming the following:

- Forrester conservatively assumes the composite organization experiences five downtime incidents per factory per month. This translates into about 90 downtime incidents for the composite in Year 1 for any single factory.
- The average downtime per incident is pegged at 8 hours before the use of MR technology, which seems conservative for a complex manufacturing process with sophisticated machinery. The reduction in factory downtime due to Microsoft’s MR solution is 23.5%.
- For manufacturing operations, it is assumed that the composite does not have sufficient HoloLens 2 devices available to adequately equip the number of technicians even when shared. Thus, the deployment ramp for the Microsoft MR technology assumed in row D5 is the much more modest operations ramp.
- The single factory revenue per hour for the composite is computed to be over $144,000 in Year 1.
- It is further assumed that any such singular machine failure or malfunction impacts one given production line per incident but is multiplied across the number of overall factories in full production mode.
- To determine the net business impact for the composite, the revenue benefit is converted into operating profits. The model assumes an operating margin of 15%.

Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- Variations in frequency of downtime incidents in factory production lines across organizations of different sizes and manufacturing complexity.
- Variations in the deployment of HoloLens devices across organizations.
- Differences in single factory revenue per hour across organizations.

Results. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $2.04 million.

Revenue Assurance From Avoided Production Downtime					
Ref.	**Metric**	**Source**	**Year 1**	**Year 2**	**Year 3**
D1	Critical incidents impacting factories	Interviews	90	92	95
D2	Hours of downtime per incident - before Microsoft HL2 MR solution deployed	Interviews	8.0	8.0	8.0
D3	Reduced downtime for factory equipment with use of Microsoft HL2 MR solution	Interviews and survey	23.5%	23.5%	23.5%
D4	Hours of downtime per incident — after Microsoft HL2 MR solution deployed	D2*(100%-D3)	6.1	6.1	6.1
D5	Deployment ramp of Microsoft HL2 MR solution — for operations	R11	10%	12%	15%
D6	Revenue per factory per hour	S9	$144,231	$146,341	$148,571
D7	Percent of individual factory production potentially disrupted per incident	Composite	10%	10%	10%
D8	Fully operational factories	R1	20.0	20.5	21.0
D9	Operating margin	B14	15%	15%	15%
Dt	Revenue assurance from avoided production downtime	D1*(D2-D4)*D5*D6*D7*D8*D9	$739,905	$943,917	$1,267,106
	Risk adjustment	↓15%			
Dtr	Revenue assurance from avoided production downtime (risk-adjusted)		$628,919	$802,329	$1,077,040
	Three-year total: $2,508,289			**Three-year present value: $2,044,023**	

FIELD TECHNICIAN PRODUCTIVITY IMPROVEMENT

Evidence and data. Interviewees noted that prior to the deployment of Microsoft's HoloLens 2 MR solution, field technicians typically had to refer to instruction manuals and reference charts during the course of their day-to-day tasks of installing and servicing manufactured products in the field. Interviewees discussed the productivity benefits enjoyed by these field technicians when having access to Microsoft's MR solution using head-up, hands-free instructions enhanced by detailed visualizations overlaid on the real world. Real-time remote collaboration enabled "see what I see" assistance from and with manufacturing SMEs to complete work or resolve issues beyond the workers' expertise without requiring extra trips. Field workers consequently saved time, prevented errors and rework, avoided excess trips, and increased their capacity.

This benefit addresses the productivity improvement for field technicians deploying Microsoft's MR solution. The key metric extracted from the survey was the increase in task efficiency for these field technicians, as it applies to the tasks that can be enhanced with MR technology.

The department manager of field services in automotive manufacturing said that "Ultimately, it comes down to time to resolution of the customer. If he can cut it from four or six days down to one day or two days, it's a benefit for all, but ultimately, it's a benefit of customer experience."

25% increase in task efficiency for field technicians utilizing MR solution for tasks that can be enhanced with MR technology

"We can use technology to see what the technician sees [and] in a certain percentage of those cases, we can resolve without physically going there and obviously fix the car and get it back to the customer. There's our initial number-one use case one."

Department manager, field tech services, automotive manufacturing

Modeling and assumptions. The focus of this benefit is productivity improvement for field workers servicing or upgrading manufactured products with the key metric being increased task efficiency for field technicians enabled by MR technology. Forrester modeled the impact for the composite organization assuming the following:

- The composite organization starts with 1,000 field technicians in Year 1 and adds a net of 40 new technicians each year based on organization growth.
- For field operations, it is assumed that the composite does not have sufficient HoloLens 2 devices available to adequately equip the entire fleet of field technicians. Thus, the deployment ramp for the Microsoft MR technology assumed in row E2 is the much more modest operations ramp. However, the number of field technicians with access to HoloLens 2 lenses is multiplied by a factor of 1.2 (line E3) because it is easier to share a lens in a field setting across 10+ users, compared to a manufacturing line.
- The percentage of tasks that are enabled by MR technology for field technicians varies by the type of equipment and the products manufactured.

The composite experiences a range of 30% to 32% from Year 1 to Year 3 is assumed — basically one-third of field technician tasks are enhanced with MR technology.

- The primary metric for this benefit, task efficiency improvement with MR for field technicians, is 25%.
- The average field technician is available for 30 hours of productive work (not traveling or in transit) for 50 weeks per year.
- The fully burdened annual salary for the average field technician is $70,000, which computes to an average hourly rate of $45. The higher rate, compared to the average manufacturing technician, is based on the assumption that field service locations will mostly be in major city hubs.

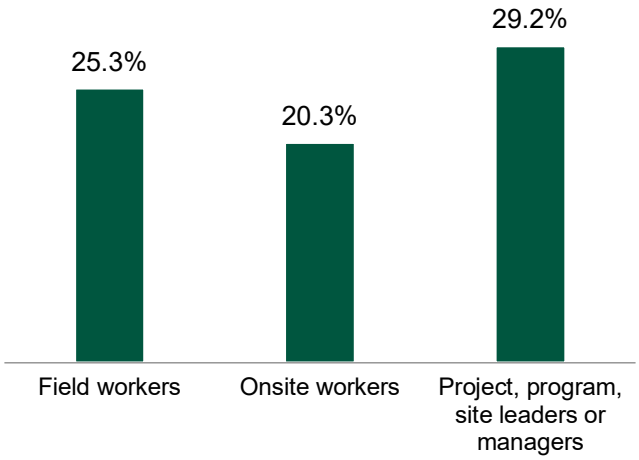
Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- MR's ability to aid task work will vary by specific supported tasks and depend on the availability of remote experts and site conditions, such as heat, sunlight, safety risks, and network connectivity.

"The idea is there if you have a less experienced technician, maybe didn't have a chance to go to a training session or we have certain repairs, they're more difficult than others. We can quickly create a guide and an individual user can use it and again, fix the car, and get it back to the customer."

Department manager, field tech services, automotive manufacturing

Potential Task Efficiencies Enabled With MR Headset



Base: 292 decision-makers working as operations professionals, frontline workers, or training/teaching/research employees in the architecture and engineering construction (AEC), education, healthcare, or manufacturing industries who use mixed reality headsets for their organizations, which have at least 1,000 employees; varies from total base of 312 due to some respondents opting to not respond to this question.
Source: A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2023

- Achieving savings relies on building relevant and high-quality MR guides and/or models, for which the availability and cost of getting the right data to feed 3D models can be a significant inhibitor.
- Recaptured savings will depend upon the number of users reached and their average labor cost.

Results. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $1.76 million.

Field Technician Productivity Improvement

Ref.	Metric	Source	Year 1	Year 2	Year 3
E1	Field technicians	S4	1,000	1,040	1,080
E2	Deployment ramp of Microsoft HL2 MR solution - for operations	R11	10%	12%	15%
E3	Subtotal: Field technicians with access to HL2 MR solution	E1*E2*120%	120	150	194
E4	Typical field technician available working hours per year	Composite	1,560	1,560	1,560
E5	Percentage of tasks enhanced with MR	Interviews	30%	31%	32%
E6	Increase in task efficiency with MR	Survey	25%	25%	25%
E7	Subtotal: Annual hours saved per field technician by HL2 MR solution	E4*E5*E6	117	121	125
E8	**Fully burdened hourly salary of skilled field technician**	**TEI standard**	**$45**	**$45**	**$45**
Et	Field technician productivity improvement	E3*E7*E8	631,800	815,443	1,093,500
	Risk adjustment	↓15%			
Etr	Field technician productivity improvement (risk-adjusted)		$537,030	$693,127	$929,475
	Three-year total: $2,159,632			**Three-year present value: $1,759,369**	

MANUFACTURING SME PRODUCTIVITY IMPROVEMENT

Evidence and data. Interviewees reported having specialized experts, or SMEs, that were employees with machine/tool-specific expertise, providing business-critical work and playing key roles in: 1) assisting with manufacturing operations problem-solving and 2) assisting field technicians with product servicing and upgrading. Prior to the deployment of Microsoft's HoloLens 2 MR solution, interviewees noted their skilled manufacturing and field technicians typically had to refer to instruction manuals and reference charts throughout the course of their day-to-day tasks as noted in benefits C and E. With the introduction of Microsoft's MR solution, expert manufacturing technicians and field technicians used remote collaboration applications, such as Remote Assist, to quickly get support from manufacturing SMEs for equipment troubleshooting and dealing with product issues in the field. These experts used MR remote support for critical needs to avoid travel, boost capacity, and address needs more efficiently. Interviewees cited a varying range of travel time required for these SMEs in responding to factory downtime incidents — sometimes even days.

This benefit addresses the productivity improvement for SMEs deploying Microsoft's MR solution to assist both skilled manufacturing and field technicians. The key metric extracted from the survey was the increase in task efficiency for these SMEs, as it applies to the tasks that could be enhanced with MR technology.

The lead solutions engineer of intelligent automation and AIOps infrastructure services in the power management manufacturing industry said: "A lot of time was getting consumed [with the] subject matter expert telling them [what to do]. We wanted to have this onboarding [happen quickly]. We started with digital training. We had the animation of each and every step — how to fix the screw and all the fun stuff."

Modeling and assumptions. There are two primary components of this benefit as it relates to the productivity of SMEs. The first is the time saved in training expert manufacturing technicians, which is the other side of benefit A that accrues to these experts. The second is the collective time saved by avoiding travel to factories (to assist expert technicians with manufacturing equipment issues) and to field locations (to assist field technicians with product-related issues). In addition to the key metric of increased task efficiency for these SMEs, the

"If there's an issue on the shop floor, you call an engineer. The engineer has to put on his gowns, go into the clean room, whatever. With Remote Assist, he just picks up the phone and launches his laptop and gives assistance remotely from his desk. And then the final use case that we're starting to do more and more is design reviews. This is something we can build a 3D virtual tool and the design engineers can review their designs in real size and walk around and explore them together."

Engineering project lead, semiconductor manufacturing

30% increase in overall task efficiency for manufacturing SMEs using HoloLens 2 with MRApps

reduction in training time metric from benefit A also comes into play. Forrester modeled the impact for the composite organization assuming the following:

- The composite organization employs 48 manufacturing and product SMEs globally.
- The training deployment ramp for Microsoft MR technology is assumed to be 63% in Year 1, 81% in Year 2, and 100% in Year 3.
- Each SME spends an average of 400 hours per year on training, whether it is for manufacturing or field technicians.
- The reduction in overall training time with Microsoft's MR solution is 20% in Year 1, 22% in Year 2, and 24% in Year 3, consistent with row A6 in benefit A.
- The number of critical manufacturing incidents that would previously require travel for these SMEs is consistent with row D1 from benefit D.
- Forrester assumes an average of 18 hours of trave time per critical incident.
- The percentage of such critical incidents that can be resolved remotely by using MR technology is assumed to be 50%. This assumption balances the average travel time estimate.
- The key metric for increased task efficiency for SMEs with the deployment of MR technology is 30%.
- The fully burdened annual salary for the average SME is $166,000 due to the sophistication of these experts. This computes to an average hourly rate of $80.

Risks. The expected financial impact is subject to risks and variation based on several factors:

- The role of experts, the tasks they support, and the frequency and distance of their travel.
- The scope, quality, and adoption of instructions and remote assistance to task workers with MR.
- The number of experts affected and their average annual salary and travel costs.

Results. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $2.2 million.

Survey respondents estimate that nearly **30% of specialized expert tasks could be supported by MR, saving each expert an average of 64 hours per task per month**

Manufacturing SME Productivity Improvement					
Ref.	**Metric**	**Source**	**Year 1**	**Year 2**	**Year 3**
F1	Manufacturing SMEs	S5	48	48	48
F2	Deployment ramp of Microsoft HL2 MR solution — for training	R12	63%	81%	100%
F3	Subtotal: Manufacturing SMEs with access to Microsoft HL2 MR solution	F1*F2	30	39	48
F4	Hours spent on training and instruction per SME	Interviews	400	400	400
F5	Reduction in training time with Microsoft HL2 MR solution	A6	20%	22%	24%
F6	Subtotal: Hours saved on training and instruction with HL2 MR solution per SME	F4*F5	80	88	96
F7	Critical incidents impacting factories	D1	90	92	95
F8	Average SME travel hours per critical incident	Interviews	18	18	18
F9	Percentage of critical incidents resolved by HL2 MR solution	Composite	50%	50%	50%
F10	Increase in task efficiency with MR	Survey	30%	30%	30%
F11	Subtotal: Hours saved by avoided time travel due to HL2 MR solution per SME	F7*F8*F9*F10	243	248	257
F12	Total hours saved per SME for training, instruction, and manufacturing operations	F6+F11	323	336	353
F13	Fully burdened hourly salary of manufacturing SME	TEI standard	$80	$80	$80
Ft	Manufacturing SME productivity improvement	F3*F12*F13	$775,200	$1,048,320	$1,355,520
	Risk adjustment	↓15%			
Ftr	Manufacturing SME productivity improvement (risk-adjusted)		$658,920	$891,072	$1,152,192
	Three-year total: $2,702,184			**Three-year present value: $2,201,100**	

IMPROVED TIME TO REVENUE FOR NEW FACTORIES RAMPING ONLINE

Evidence and data. For the interviewees, building and equipping an Industry 4.0 factory for complex products was a multiyear journey. The construction of the building and infrastructure (e.g., electrical wiring, cabling, water and cooling, etc.) was beyond the scope of this study. Planning the production lines with the sophisticated machinery that has been discussed — the equipping component — came up for discussion during several interviews. In the prior state, such planning required working closely with equipment vendors, estimating size and form-factors, creating 3D models, etc. But the ultimate test came when the equipment arrived at the factory and was physically installed. Interviewees spoke of variances in specifications and human errors in estimating functional flow that led to equipment not fitting, requiring rework (with each engineering change order being upwards of $10,000). Inevitably, this led to delays in getting new factory lines and new factories ramping up production.

With the introduction of Microsoft's MR solution, creating digital twins of equipment during the factory/line-planning process with HoloLens 2 and RA ensured that machines would fit and would not require engineering change (and thus more cost). With up-front planning, interviewees cited a significant reduction in the effort required to install equipment when building out a new factory line. Plus, the more significant impact on the business was that up-front planning allowed for faster time to revenue for new production lines.

More than 85% productivity improvement for equipping, installing, and calibrating each new production line by utilizing HoloLens 2 with MRApps for virtual factory planning

"Vendor would initially build their equipment. It will arrive on-site. And then, the plant would discover, 'Oh, hey, this wasn't built quite the way we would like it. We want to change these features of this equipment and have that changed.' Well, the vendor would charge us a change request to be able to make those changes. And so, by being able to utilize the HoloLens, we essentially were able to eliminate some of those potential change request that would have happened."

Lead solution engineer, intelligent automation and AIOps infrastructure services, power management manufacturing

There are two components of this benefit: the reduction in effort required to install machinery for each incremental production line and faster time to revenue for each incremental line. The key metric computed in the model, based on data provided by the interviewees, was more than an 80% productivity boost for manufacturing technicians installing equipment for a new production line (savings in FTEs and number of hours). The faster time to revenues for a new production line was also based on data provided by interviewees. Interviewees shared examples of door-to-floor productivity improvement, along with data insights, including the following:

- The lead solutions engineer of intelligent automation and AIOps infrastructure services provided their perspective: "Typically in the past, the plant would wait for all of that equipment to

arrive on-site and have to use the physical equipment to be able to perform those analyses, and it usually took four to five employees. And so, we have total labor hours of around 60 hours for each piece of equipment that would arrive. With the way that we are able to utilize the HoloLens and can still work on that equipment, the plant was able to cut that down to essentially two people in about 10 labor hours for each of the equipment."

- The engineering project lead for a semiconductor manufacturer spoke about how their organization used Guides as part of the process of building new factories: "Where we've used it and what we use [Guides] for is that as we're building our factories … Our first team, the construction team, would use a HoloLens to overlay digital models for QA/QC control and to minimize rework, our clash on what we would call base build." The engineering project lead for a semiconductor manufacturer also said: "What [Guides] can do is very much prevent delays because often these things need to happen in a sequence. And if something falls behind because something needs an expensive rework or something wasn't caught, then it could have a knock-on effect of 10 other things and it could delay a whole thing that would then usually be pulled back in."
- The senior training program manager at a semiconductor supplier stated: "Let's say I'm building a new fab. I'm going to equip it with mixed equipment but there's a whole bunch of our stuff in there and if I can sort of visualize the space and you give me the equipment parameters. I'm now building a space on this fab line or whatever and I'm able to prepare my facility for the equipment that's coming in. In fact, I may even give you feedback and say, 'Can you cut this down by an inch or centimeter something like that?' And, therefore, my time to ramp up a new fab is reduced by two or three weeks. That's time to money."

"Based off of the 3D models that the vendor provided to the plant … after performing that analysis, the plant was able to get back with the vendor and say, 'Hey, we need to make a few adjustments here and there for a safety issue or for a better ergonomic issue or material flow.' And so, we were able to make those changes to the equipment before any equipment was actually built so that when they go to build it, everything is built in the way that works well for the plant."

Lead solution engineer, intelligent automation and AIOps infrastructure services, power management manufacturing

- In terms of the second component of this benefit, which is faster time to revenues, only one interviewee was willing to estimate the likely reduction in time to ramp a new production line with the use of MR technology, which was two weeks (cited as a conservative estimate).

Modeling and assumptions. The focus of this benefit is faster time to revenue enabled with Microsoft's MR solution for ramping up new production lines with the key metric being improved productivity for factory technicians equipping each new production line. The second component of this benefit is the revenues derived by ramping each new production line faster than before as a function of planning each line with digital twins by deploying MR

technology. Forrester modeled the impact for the composite organization assuming the following:

- The composite brings on five new production lines each year and each production line has 10 unique equipment components.
- In the prior state, it is assumed that five factory workers are needed for 60 hours for each new piece of equipment installed.
- By using MR technology to build digital twins of each piece of equipment and a 3D rendering of the factory layout, the composite deploys each new piece of equipment using two factory workers for 20 hours each. This computes into a productivity improvement of 86.7% for equipping, installing, and calibrating each new production line.
- For manufacturing SMEs and other experts involved in the virtualization of the planning new production lines, it is assumed that a sufficient number of HoloLens 2 devices are available for these efforts. Thus, there is no deployment ramp adjustment for the first component of this benefit.
- Given the reduction in hours to install and calibrate all the equipment for a new production line (400 hours per line), Forrester estimates that the composite organization likely accelerates the time to ramp a new production line by two weeks, or 192 hours for the composite, which runs three 32-hour shifts per week.
- The annual revenue per production line per hour for the composite is $14,423 in Year 1.
- Line G11 applies the “training” deployment ramp, vs. the operations production ramp for Microsoft’s MR technology. Again, this is because this acceleration in time is not deterred by the availability of sufficient devices on the production line, but rather used by a small group of manufacturing SMEs and other production planning experts.
- To determine the net business impact for the composite for the second component of this benefit, the revenue benefit is converted into operating profits (which is assumed at 15%). That amount is added to the first component of this benefit — the productivity savings for installing equipment for new lines.

Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- Variations in the number of new production lines brought on per year across organizations.

MR Headset Impact Extends Throughout Organizations

Role	Estimated Number Of Impacted Resources	Percentage Of Tasks Potentially Supported By MR	Average Hours Currently Spent On Supported Tasks Per Individual Per month
Field workers	41.7	27.2%	86.6
Onsite workers	124.7	16.0%	96.8
Project, program, site leaders or managers	23.6	17.8%	62.6
Specialized experts	24.8	28.5%	63.9
Field workers	41.7	27.2%	86.6

Base: 312 decision-makers working as operations professionals, frontline workers, or training/teaching/research employees in the architecture and engineering construction (AEC), education, healthcare, or manufacturing industries who use mixed reality headsets for their organizations, which have at least 1,000 employees
Source: A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2023

- Differences across organizations in the number of factory workers needed for each new piece of equipment.
- Variations in annual revenue per production line per hour across organizations.

Results. To account for these risks, Forrester adjusted this benefit downward by 20%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $3.68 million.

Improved Time To Revenue For New Factories Ramping Online

Ref.	Metric	Source	Year 1	Year 2	Year 3
G1	Incremental production lines added	(R1-R1$_{PY}$)*R6	5	5	5
G2	Production lines per factory	R6	10	10	10
G3	Factory employees needed per machine for new factory layout - before Microsoft HL2 MR solution	Interviews	5	5	5
G4	Factory employees needed per machine for new factory layout - after Microsoft HL2 MR solution	Interviews	2	2	2
G5	Hours to install each machine for a new production line - before Microsoft HL2 MR solution	Interviews	60	60	60
G6	Hours to install each machine for a new production line - after Microsoft HL2 MR solution	Interviews	20	20	20
G7	Fully-burdened hourly salary of average manufacturing technician	A8	$26	$26	$26
G8	Subtotal: Cost savings derived by utilizing MR solution for new production lines layout	G1*G2*(G3-G4)*(G5-G6)*G7	$156,000	$156,000	$156,000
G9	Reduction in hours required to ramp each incremental production line	Interviews	192	192	192
G10	Revenue per production line per hour	S10	$14,423	$14,634	$14,857
G11	Deployment ramp of Microsoft HL2 MR solution — for training	R12	63%	81%	100%
G12	Subtotal: Faster time to revenue for new production lines	G1*G9*G10*G11	$8,723,030	$11,379,398	$14,262,720
G13	Operating margin	B14	15%	15%	15%
Gt	Improved time to revenue for new factories ramping online	G8+G12*G13	$1,464,455	$1,862,910	$2,295,408
	Risk adjustment	↓20%			
Gtr	Improved time to revenue for new factories ramping online (risk-adjusted)		$1,171,564	$1,490,328	$1,836,326
	Three-year total: $4,498,218			**Three-year present value: $3,676,393**	

OVERALL TRAVEL AND INCIDENTALS SAVINGS

Evidence and data. Replacing expert travel with remote expertise and self-guided task worker instruction saved the interviewees' organizations significant travel and incidentals costs (e.g., flights, cars, hotels, food and beverage, etc.) in addition to labor saved (which is captured separately, under productivity benefits). Interviewees noted costs saved were typically between $2,500 to $3,500 per trip. Avoided regional field worker trips for rework and follow-up visits also generated minor cost savings for fuel and incidentals. Training travel cost savings for new technicians were also experienced. Field technicians and manufacturing SMEs reduced overall travel due to MR technology.

Interviewees shared many examples of overall travel and incidentals savings benefits, including the following:

- Most interviewees reduced or eliminated one to two weeks of travel for new technicians who usually received some baseline training at hubs.
- Field technicians reduced their travel time by 20% to 35% by not having to travel, even locally, to assist customers with product issues that could now be handled by MR technology.
- Manufacturing SMEs previously had to be called into a factory that was experiencing equipment-related downtime. With Microsoft's MR technology, the interviewees' organizations avoided between three to 12 visits per factory location per week for these SMEs.

Number of training-related trips **reduced by 45%**

Number of field technician trips **reduced by 20%**

"The beauty of HoloLens is that it allows you to have flexibility. You can pull that digital twin up anywhere. I can pull it up in my office, I could be in a conference room, wherever, you could pull this digital twin up."

Director of augmented engineering services, pharmaceuticals manufacturing

Modeling and assumptions. Forrester modeled the impact for the composite organization assuming the following:

- From a training standpoint, new technicians typically took a one-week trip in the prior state, while manufacturing SMEs (their trainers) used to take two one-week trips previously. The composite organization reduces 45% of training-related travel.
- The expense of a one-week trip — for both new technicians and SMEs — is estimated to be $2,500 for planned training purposes.
- Field technicians typically spent 25% of their time on travel before the use of MR technology. Field technicians eliminate 20% of this travel time due to MR technology.
- The cost per skilled technician per hour for local travel is based on their hourly expense plus $10 per hour on incidentals.
- For manufacturing SMEs who previously had to be called into each critical incident at any given factory, a 50% reduction in such travel is achieved with MR technology consistent with benefit F.

- The expense of a critical incident trip for an SME is conservatively estimated at $2,500, which is likely understated for trips that are arranged at the last minute.

Risks. The expected financial impact is subject to risks and variation based on several factors, including the following:

- The scope, quality, and adoption ramp of MR technology.
- The number of new technicians and SME trainers involved in training each year.
- The number of SMEs and field workers affected and their frequency of trips.
- The typical distance, length, tier, and amount of advance notice of avoided trips for SMEs.
- The typical travel cost and incidentals incurred per field technician trip.

Results. To account for these risks, Forrester adjusted this benefit downward by 10%, yielding a three-year, risk-adjusted total PV (discounted at 10%) of $2.09 million.

"It's great for my team, we can go on to the next car and, if the dealer can fix the car in one or two days, it allows them to use this technical capacity now somewhere else."

Department manager, field tech services, automotive manufacturing

Overall Travel And Incidentals Savings

Ref.	Metric	Source	Year 1	Year 2	Year 3
H1	New skilled factory technicians hired	A3	443	450	458
H2	Manufacturing SMEs	F1	48	48	48
H3	Total average number of training-related trips required annually - before HL2	H1*1+H2*2	539	546	554
H4	Reduction in number of trips due to Microsoft HL2 MR solution	Interviews and survey	45%	45%	45%
H5	Avoided trips per trainer/trainee - after Microsoft HL2 MR solution	H3*H4	243	246	249
H6	Average cost savings per trainer/trainee trip	Interviews and survey	$2,500	$2,500	$2,500
H7	Subtotal: Total travel cost savings for training	H5*H6	$607,500	$615,000	$622,500
H8	Field technicians with access to HL2 MR solution	E3	120	150	194
H9	Percentage of field technician tasks enhanced with MR	E5	30%	31%	32%
H10	Typical field technician hours spent on travel before MR	E4*25%	390	390	390
H11	Reduction in number of trips due to Microsoft HL2 MR solution	Interviews and survey	20%	20%	20%
H12	Average travel and incidentals hourly cost per skilled field technician	E8+$10	$55	$55	$55
H13	Subtotal: Total travel cost savings for field technicians	H8*H9*H10*H11*H12	$154,440	$199,166	$266,872
H14	Critical incidents impacting factories	F7	90	92	95
H15	Reduction in number of trips due to Microsoft HL2 MR solution	F9	50%	50%	50%
H16	Average cost savings per manufacturing SME trip	Interviews and survey	$2,500	$2,500	$2,500
H17	Subtotal: Total travel cost savings for manufacturing SMEs	H14*H15*H16	$112,500	$115,000	$118,750
Ht	Overall travel and incidentals savings	H7+H13+H17	$874,440	$929,166	$1,008,122
	Risk adjustment	↓10%			
Htr	Overall travel and incidentals savings (risk-adjusted)		$786,996	$836,249	$907,310
	Three-year total: $2,530,555			**Three-year present value: $2,088,241**	

QUALITATIVE BENEFITS

Interviewees mentioned the following additional benefits that their organizations experienced but were not able to quantify include:

- **Furthered sustainability goals.** MR instructions with HoloLens 2 allowed the interviewees' employees to access training online and from anywhere, reducing the need for training-related travel. This saved time and money and helped meet sustainability goals more successfully since it reduced emissions associated with travel. This also reduced training material waste.
- **Hands-free and remote training.** Interviewees noted that holographic work instruction through Dynamics 365 Guides accessible via HoloLens 2 improved employees' productivity with 3D, step-by-step, holographic step cards. This reduced errors, increased efficiency, ensured that procedure was followed safely, and overall improved the quality of work. Not only could training be accessed anywhere, but training could also be accessed in the work environment — not tied to a desk or mobile screen — to keep hands free to allow employees to receive training at their worksite. An IT technician could review a schematic on top of a device instead of watching a tutorial video. An employee working on a manufacturing line could see the next process step outlined over machinery while they were working at their station. The department manager in field tech services at an automotive manufacturing organization said: "Yes, you can use a mobile tablet or phone for technicians and experts to see the same thing, but they can't work at the same time. And that's why we chose here to use HoloLens. So, it gives the technician the flexibility to have both hands available to do what you must do."
- **Improved quality with enhanced employee experience.** Providing an immersive training experience that allowed the interviewees' employees the ability to train wherever, whenever in a head-up, hands-free environment. Along with more focused and efficient training sessions, interviewees' organizations developed (and continually updated) process guides to conveniently help employees follow process steps or locate a best practice. This reduced errors and improved the quality of work.
- **Attract, hire, and retain higher-quality employees.** Interviewees noted their employees wanted to avoid spending time looking for information and wanted to get work done. With HoloLens 2, leveraging new technologies helped make work more interesting by providing new experiences and avoiding repetitive tasks. This improved employee experience, leading to improved retention and avoided hiring and transition costs — and avoided the loss of experienced employees and institutional memory. Leveraging HoloLens 2 and MRApps differentiated company recruitment strategies by using the latest and greatest technology, which also led to cost saving in acquiring and retaining high-talented employees.
- **Protected health and safety.** According to interviewees, MR instructions helped employees get through repetitive tasks more quickly — and could protect life and health. Not following procedures exactly as intended could lead to dangerous scenarios in a manufacturing context.

"The benefit we see in HoloLens when a technician works, you have the device and you're hands-free — you can work."

Department manager, field tech services, automotive manufacturing

HoloLens 2 with Guides enabled technicians to follow instructions that provided guidance and training while doing their work, ensuring procedures are followed safely.

- **Improved compliance.** Process guides helped technicians using HoloLens 2 follow the steps properly, helping meet compliance standards.

FLEXIBILITY

The value of flexibility is unique to each customer. There are multiple scenarios in which a customer might implement HoloLens 2 with MRApps and later realize additional uses and business opportunities, including:

- **Expand the deployment of HoloLens 2 with MRApps to additional departments and roles.** Businesses that adopt HoloLens 2 may find that there are more use cases for MRApps than were initially planned. With some additional investment for expansion, organizations can gain greater benefits by providing improved training quality and efficiency improvements to more employees.
- **Redesign business processes and enhance decision-making by analyzing MR device and application data**. With the ability to record trouble shooting scenarios and centrally collect and analyze such data, organizations may be better positioned to redesign and enhance existing processes.
- **Adaptability for unexpected business challenges.** HoloLens 2 allows business to rapidly adapt to unexpected challenges while avoiding disruptions to business continuity, The engineering project lead in the semiconductor manufacturing industry said, “We used it extensively and it paid for itself really just for one use case over COVID-19.”

Flexibility would also be quantified when evaluated as part of a specific project (described in more detail in Appendix A).

“Our primary use cases for the device are remote expert assist, technical training and to a lesser extent and BIM for tool install. And we’ve been using the HoloLens, as I said kicked off in 2020 and now in 2023, we have a couple of hundred headsets, and we’ve trained a few thousand people.”

Engineering project lead, semiconductor manufacturer

Analysis Of Costs

Quantified cost data as applied to the composite

Total Costs							
Ref.	**Cost**	**Initial**	**Year 1**	**Year 2**	**Year 3**	**Total**	**Present Value**
Itr	HoloLens 2 devices	$386,085	$134,411	$139,986	$29,736	$690,218	$646,308
Jtr	Subscriptions and consumption	$0	$583,000	$851,840	$1,069,420	$2,504,260	$2,037,471
Ktr	Planning, implementation, and management	$1,578,984	$1,051,952	$792,616	$863,896	$4,287,448	$3,839,416
Ltr	Training	$0	$178,640	$63,168	$39,515	$281,323	$244,293
	Total costs (risk-adjusted)	$1,965,069	$1,948,003	$1,847,610	$2,002,567	$7,763,248	$6,767,488

HOLOLENS 2 DEVICES

Evidence and data. Interviewees noted that their organization could purchase HoloLens 2 devices directly from Microsoft or through a partner. Devices could be dedicated to a user or shared by multiple users. Some interviewees noted their organizations required specialized devices, such as the Industrial Edition or third-party hard hat options.

Modeling and assumptions. Forrester modeled the cost for the composite organization assuming:

- The required number of devices are purchased at the beginning of each year for a retail price of $3,500 per HoloLens 2.
- Overhead to replace devices that are damaged or overused due to sharing, etc., is assumed to be 3% of devices annually.

Risks. Forrester uncovered low risks that may impact device costs, including the selected use cases, the number of sites and users, travel and site damage risk, network integration needs, device availability, existing usage of Microsoft services, and any needs for specialized Industrial Edition or hard hat devices.

Results. To account for these risks, Forrester adjusted this cost upward by 5%, yielding a three-year, risk-adjusted total PV of $646,000.

HoloLens 2 Devices						
Ref.	**Metric**	**Source**	**Initial**	**Year 1**	**Year 2**	**Year 3**
I1	HoloLens 2 devices	$R10_{NY}$	100	130	160	160
I2	Cost per HoloLens 2 device	Composite	$3,500	$3,500	$3,500	$3,500
I3	Subtotal: Initial device purchase costs	$(I1\text{-}I1_{PY})*I2$	$350,000	$105,000	$105,000	$0
I4	Overhead for device replacements	Interviews	3%	3%	3%	3%
I5	Device replacement costs	I1*I2*I4	$10,500	$13,650	$16,800	$16,800
I6	Mobile device management subscription per device, per month	Composite	$6	$6	$6	$6
I7	Mobile device management (MDM) subscriptions	I1*I6*12	$7,200	$9,360	$11,520	$11,520
It	HoloLens 2 devices	I3+I5+I7	$367,700	$128,010	$133,320	$28,320
	Risk adjustment	↑5%				
Itr	HoloLens 2 devices (risk-adjusted)		$386,085	$134,411	$139,986	$29,736
	Three-year total: $690,218			**Three-year present value: $646,308**		

SUBSCRIPTIONS AND CONSUMPTION

Evidence and data. Interviewees noted that most mixed-reality apps from Microsoft and ISV partners were priced using a per-user subscription fee with additional costs incurred for Azure services consumption. Device-based licensing was an option for only some applications. The cost of custom-developed apps was instead based on internal and system integrator (SI) labor rather than subscriptions.

Modeling and assumptions. Forrester modeled the cost for the composite organization assuming:

- The composite leverages prebuilt apps that provide capabilities for instructions, visualization, and remote collaboration. The specific applications are Microsoft's Dynamic 365 Guides and Remote Assist (RA). The current list price of $65 per device per user for both applications (RA and Guides) is assumed.
- The composite assigns subscriptions to 500 end users in Year 1, 650 in Year 2, and 800 in Year 3, based on a general ratio of five users per HoloLens 2 device (whether shared on the factory floor, in field locations, or where SMEs are located). This includes subscriptions used for the innovation team and factory planning and digital twin virtualization teams.
- The composite incurs Azure costs of up to $320,000 by Year 3, growing as usage of the applications increases over time.

The composite incurs up to $40,000 in additional costs to provide network connectivity for sites or field users without dependable access.

Risks. Costs will vary based on the selected applications and number of users. Interviewees noted that their largest inhibitor to scaling MR was user-based licensing models that became prohibitively expensive and difficult to manage for large numbers of infrequent users, such as trainees. Readers are strongly advised to: 1) carefully select the use cases and end users for which subscriptions are assigned, 2) conduct regular and diligent user profile

management to control costs, and 3) monitor usage of Azure minutes.

Results. To account for these risks, Forrester adjusted this cost upward by 10%, yielding a three-year, risk-adjusted total PV of $2.04 million.

Subscriptions And Consumption

Ref.	Metric	Source	Initial	Year 1	Year 2	Year 3
J1	Cumulative licensed RA and Guides users	R13	0	500	680	790
J2	Average annual subscription cost per user for Guides and Remote Assist	Composite	$780	$780	$780	$780
J3	Subtotal: Application subscriptions	J1*J2	$0	$390,000	$530,400	$616,200
J4	Azure cloud services for access and consumption	Interviews	$0	$100,000	$204,000	$316,000
J5	Internet accessibility	Interviews	$0	$40,000	$40,000	$40,000
Jt	Subscriptions and consumption	J3+J4+J5	$0	$530,000	$774,400	$972,200
	Risk adjustment	↑10%				
Jtr	Subscriptions and consumption (risk-adjusted)		$0	$583,000	$851,840	$1,069,420
	Three-year total: $2,504,260			**Three-year present value: $2,037,471**		

PLANNING, IMPLEMENTATION, AND MANAGEMENT

Evidence and data. Interviewees noted that implementation costs and labor for mixed reality continued to fall every year as more expertise and apps became available and as use cases became better documented and defined.

However, mixed reality remained at the leading edge. Successful implementations required significant work to build, test, and evangelize. The time, cost, expertise, and stakeholder buy-in needed to deploy mixed reality and ensure successful adoption must not be underestimated. Mixed reality success required much more than deploying software; entire processes (e.g., training methods) must be changed with stakeholders driving change forward.

While remote collaboration could often be deployed quickly and easily with minimal change management, significant effort must be dedicated to work instructions and visualization. Teams must document processes, map out process changes, gather or create 3D assets, build instructions, and test and refine iteratively until the visualizations and instructions provide consistent value to users. Frontline workers and their managers must trust the materials and find the experience to be both relevant and high quality.

Modeling and assumptions. Forrester modeled the cost for the composite organization assuming:

- The composite organization utilizes all manufacturing SMEs (at 10% to 40% of their time) for preparing training materials in conjunction with the innovation team. Each of these SMEs also spend 50 hours a year working with the innovation team on new factory planning.
- The composite organization has an 18-person team that runs key innovation efforts, including the mixed reality deployment. This team includes one extended reality (XR) leader, two developers, four technical project managers, seven 3D designers, and four ITOps personnel. The team is partially dedicated to mixed reality.
- The composite deploys mixed reality apps for instruction, visualization, and remote collaboration over a one-year initial period. Time dedicated to the initial deployment includes: 1) 1,248 hours each for the XR leader and the developers; 2) 1,664 hours for each of the four technical project managers; 3) 1,040 hours for each of the seven 3D designers; and 4) 520 hours for each of the ITOps FTEs.
- The composite organization dedicates significant further development and fine-tuning in Year 1 to extract greater value out of the applications, with benefits fully realized by Year 2 of the analysis. The team continues to maintain and enhance the mixed reality investment moving forward. Time spent by all members of the innovation team decreases in Year 1 and falls further in Years 2 and 3 compared to the first-year baseline.
- In addition to the 18-person MR team, nine test users provide two weeks of labor to testing and providing feedback on the apps prior to deployment, plus one week per user in Year 1 and 2.5 days per user in subsequent years.
- The composite incurs $100,000 in initial costs for a system integrator (SI) to provide implementation support, plus an additional $50,000 in Year 1.
- The innovation team holds a retainer expense budget of $50,000 per year to support miscellaneous costs of the investment, such as device-shipping costs, travel costs for on-site app testing, or project manager travel for training of first-time HoloLens 2 users.

Risks. Costs will vary significantly per organization depending on a range of factors, including:

- Scale of the deployment and use cases included.

- Ability to find and leverage prebuilt apps for these use cases. Customization and custom development can be much more expensive.
- The number and complexity of mixed reality instructions that need to be created.
- The amount and quality of preexisting 3D digital assets and instructions materials that can be imported and used for mixed reality.
- Potential for excess costs due to organizational constraints, such as high levels of customization or rigid security, network access, and device management policies (particularly impactful for highly regulated industries like healthcare).

Results. To account for these risks, Forrester adjusted this cost upward by 10%, yielding a three-year, risk-adjusted total PV of $3.84 million.

Planning, Implementation, And Management

Ref.	Metric	Source	Initial	Year 1	Year 2	Year 3
K1	Manufacturing SMEs with access to Microsoft HL2 MR solution	F3	30	30	39	48
K2	Annual hours spent on MR-related training materials for training and operations per SME	Composite	32	80	40	40
K3	Annual hours spent on MR-related new factory planning per SME	Interviews	50	50	50	50
K4	Fully burdened hourly salary of manufacturing SME	F13	$80	$80	$80	$80
K5	Subtotal: Manufacturing SME costs related to MR	K1*(K2+K3)*K4	$196,800	$312,000	$280,800	$345,600
K6	3D designer hours	Interviews	7,280	3,640	4,160	4,160
K7	Fully burdened hourly salary of 3D designer	TEI standard	$50	$50	$50	$50
K8	Subtotal: 3D designer costs	K6*K7	$364,000	$182,000	$208,000	$208,000
K9	Developer hours	Interviews	3,744	1,872	936	936
K10	Fully burdened hourly salary of developer	TEI standard	$80	$80	$80	$80
K11	Subtotal: Developer costs	K9*K10	$299,520	$149,760	$74,880	$74,880
K12	ITOps hours	Interviews	2,080	1,040	520	520
K13	Fully burdened hourly salary of ITOps FTE	TEI standard	$50	$50	$50	$50
K14	Subtotal: IT admin costs	K12*K13	$104,000	$52,000	$26,000	$26,000
K15	Project management hours	Interviews	6,656	3,328	1,664	1,664
K16	Fully burdened hourly salary of project management FTE	TEI standard	$45	$45	$45	$45
K17	Subtotal: Project management costs	K15*K16	$299,520	$149,760	$74,880	$74,880
K18	Test user hours	Interviews	720	360	200	200
K19	Fully burdened hourly salary of test user	TEI standard	$30	$30	$30	$30
K20	Subtotal: Test user costs	K18*K19	$21,600	$10,800	$6,000	$6,000
K21	Professional services costs	Partner data	$100,000	$50,000	$0	$0
K22	Expense budget for shipping, travel, and other hardware/software needs	Interviews	$50,000	$50,000	$50,000	$50,000
Kt	Planning, implementation, and management	K5+K8+K11+K14+K17+K20+K21+K22	$1,435,440	$956,320	$720,560	$785,360
	Risk adjustment	↑10%				
Ktr	Planning, implementation, and management (risk-adjusted)		$1,578,984	$1,051,952	$792,616	$863,896
	Three-year total: $4,287,448			**Three-year present value: $3,839,416**		

TRAINING

Evidence and data. Interviewees noted that their users had to learn to use HoloLens 2 and the apps running on it before they could benefit from their new mixed reality work experiences. They also had to be convinced to use it in their day-to-day work. Investing in user training was critical to drive real adoption of mixed reality and achieve business results. Underinvesting in training led to disappointing results; compared to the potential benefit, the costs of a high-quality and well-supported mixed reality training program were easily recouped.

Aside from learning to use the HoloLens 2 itself, training was particularly important for addressing two adjacent needs commonly experienced by interviewees when deploying mixed reality: 1) the need to conduct additional safety training to ensure that users followed rigid safety protocols even after donning the headset and 2) the need to conduct change management training around process redesign that often accompanied the development of MR instructions.

Modeling and assumptions. Forrester conservatively modeled user training costs for the composite organization. In most cases, users at the composite organization require anywhere from 2 hours to 8 hours of training to gain comfort and proficiency with the HoloLens 2 device and MR applications. Given the scale of the composite's deployment, Forrester has modeled 8 hours of training for all 800 users who interact with mixed reality, including those being trained for their work tasks with HoloLens 2.

Risks. Costs will vary significantly per organization depending on a range of factors, including:

- Additional safety training to ensure that users follow safety protocol after donning the headset.
- Additional training that may be needed for change management and process redesign that often occurs when mixed reality instructions are deployed.

Results. To account for these risks, Forrester adjusted this cost upward by 10%, yielding a three-year, risk-adjusted total PV of $244,293.

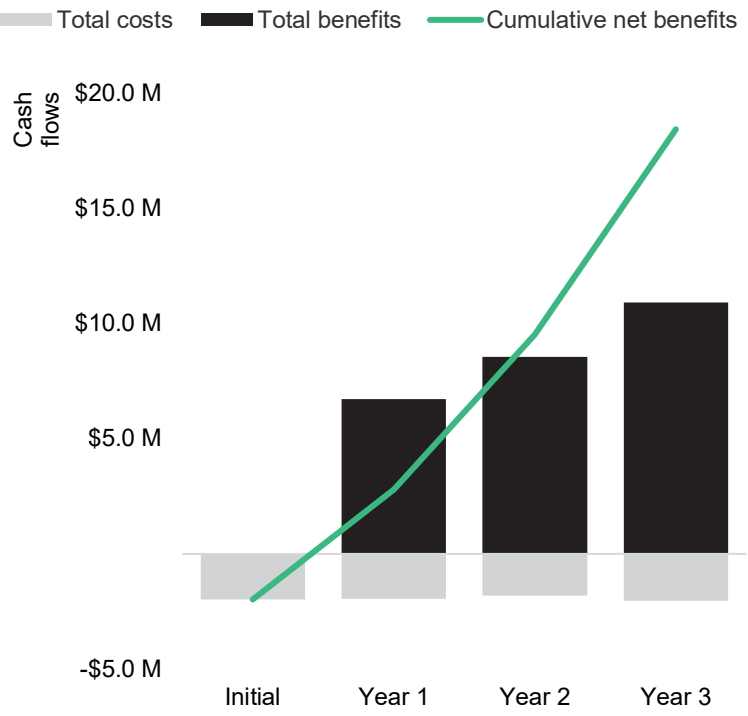
Training

Ref.	Metric	Source	Initial	Year 1	Year 2	Year 3
L1	Total MR users including trainees and device sharing	J1	0	500	680	790
L2	Percent of users that are new to MR	(L1-$L1_{PY}$)/L1	100%	100%	26%	14%
L3	Training and set up hours per new MR user	Interviews	8	8	8	8
L4	Average fully burdened hourly salary across all MR users	TEI standard	$41	$41	$41	$41
Lt	Training	L1*L2*L3*L4	$0	$162,400	$57,425	$35,923
	Risk adjustment	↑10%				
Ltr	Training (risk-adjusted)		$0	$178,640	$63,168	$39,515
	Three-year total: $281,323			**Three-year present value: $244,293**		

Financial Summary

CONSOLIDATED THREE-YEAR RISK-ADJUSTED METRICS

Cash Flow Chart (Risk-Adjusted)



The financial results calculated in the Benefits and Costs sections can be used to determine the ROI, NPV, and payback period for the composite organization's investment. Forrester assumes a yearly discount rate of 10% for this analysis.

These risk-adjusted ROI, NPV, and payback period values are determined by applying risk-adjustment factors to the unadjusted results in each Benefit and Cost section.

Cash Flow Analysis (Risk-Adjusted Estimates)

	Initial	Year 1	Year 2	Year 3	Total	Present Value
Total costs	($1,965,069)	($1,948,003)	($1,847,610)	($2,002,567)	($7,763,248)	($6,767,488)
Total benefits	$0	$6,722,786	$8,546,305	$10,930,503	$26,199,594	$21,386,933
Net benefits	($1,965,069)	$4,774,783	$6,698,695	$8,927,936	$18,436,345	$14,619,445
ROI						216%
Payback						<6 months

Appendix A: Total Economic Impact

Total Economic Impact is a methodology developed by Forrester Research that enhances a company's technology decision-making processes and assists vendors in communicating the value proposition of their products and services to clients. The TEI methodology helps companies demonstrate, justify, and realize the tangible value of IT initiatives to both senior management and other key business stakeholders.

TOTAL ECONOMIC IMPACT APPROACH

Benefits represent the value delivered to the business by the product. The TEI methodology places equal weight on the measure of benefits and the measure of costs, allowing for a full examination of the effect of the technology on the entire organization.

Costs consider all expenses necessary to deliver the proposed value, or benefits, of the product. The cost category within TEI captures incremental costs over the existing environment for ongoing costs associated with the solution.

Flexibility represents the strategic value that can be obtained for some future additional investment building on top of the initial investment already made. Having the ability to capture that benefit has a PV that can be estimated.

Risks measure the uncertainty of benefit and cost estimates given: 1) the likelihood that estimates will meet original projections and 2) the likelihood that estimates will be tracked over time. TEI risk factors are based on "triangular distribution."

The initial investment column contains costs incurred at "time 0" or at the beginning of Year 1 that are not discounted. All other cash flows are discounted using the discount rate at the end of the year. PV calculations are calculated for each total cost and benefit estimate. NPV calculations in the summary tables are the sum of the initial investment and the discounted cash flows in each year. Sums and present value calculations of the Total Benefits, Total Costs, and Cash Flow tables may not exactly add up, as some rounding may occur.

PRESENT VALUE (PV)

The present or current value of (discounted) cost and benefit estimates given at an interest rate (the discount rate). The PV of costs and benefits feed into the total NPV of cash flows.

NET PRESENT VALUE (NPV)

The present or current value of (discounted) future net cash flows given an interest rate (the discount rate). A positive project NPV normally indicates that the investment should be made, unless other projects have higher NPVs.

RETURN ON INVESTMENT (ROI)

A project's expected return in percentage terms. ROI is calculated by dividing net benefits (benefits less costs) by costs.

DISCOUNT RATE

The interest rate used in cash flow analysis to take into account the time value of money. Organizations typically use discount rates between 8% and 16%.

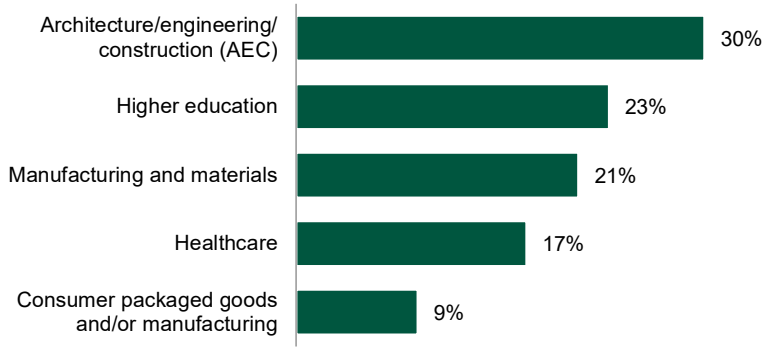
PAYBACK PERIOD

The breakeven point for an investment. This is the point in time at which net benefits (benefits minus costs) equal initial investment or cost.

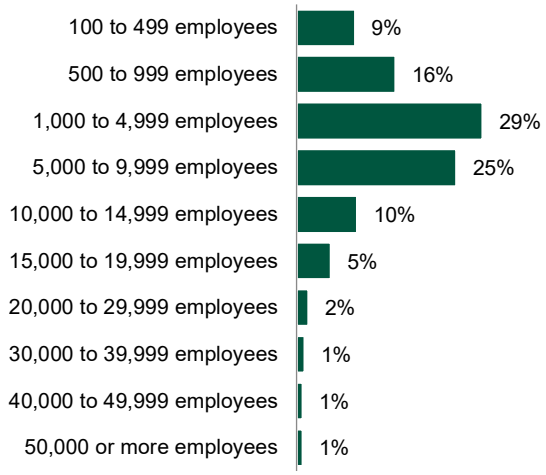
Appendix B: Survey Demographics

Survey Demographics

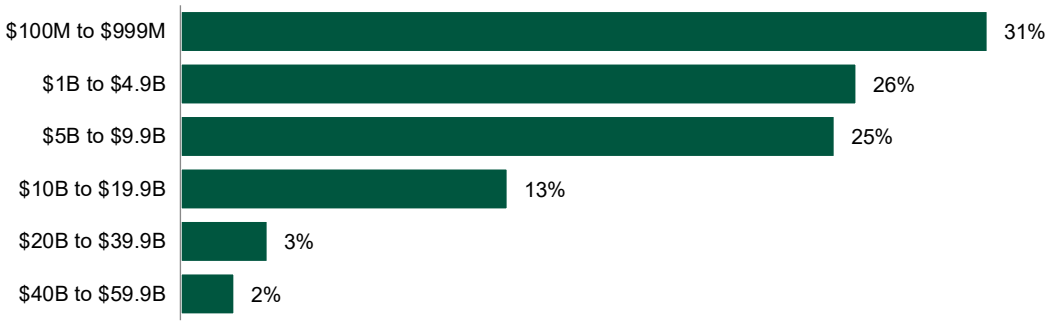
"Which of the following best describes the industry to which your company belongs?"



"Using your best estimate, how many employees work for your firm/organization worldwide?"



"Using your best estimate, what is your organization's annual revenue (USD)?"



Base: 240 decision-makers working as operations professionals, frontline workers, or training/teaching/research employees in the architecture and engineering construction (AEC), education, healthcare, or manufacturing industries who use mixed reality headsets for their organizations, which have at least 1,000 employees; varies from total base of 312 due to some respondents opting to not respond to this question.
Source: A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2023

Appendix C: Supplemental Information

RELATED FORRESTER RESEARCH

"A Reality Check For Enterprise Extended Reality And Metaverse," Forrester Research, Inc., April 27, 2023.

"Building The Beginnings Of The Metaverse," Forrester Research, Inc., January 24, 2023.

"Smart Manufacturing: Don't Forget The People," Forrester Research, Inc., October 4, 2022.

"The Forrester Wave™: Digital Operations Platforms For Manufacturing And Distribution, Q3 2022," Forrester Research, Inc., September 26, 2022.

"The Future Of Manufacturing," Forrester Research, Inc., September 9, 2022.

"How To Successfully Scale Your Augmented Reality Device Rollout," Forrester Research, Inc., August 3, 2021.

ONLINE RESOURCES

Laia Tremosa, "Beyond AR vs. VR: What is the Difference between AR vs. MR vs. VR vs. XR?," Interaction Design Foundation, August 2023.

Appendix D: Endnotes

[1] Total Economic Impact is a methodology developed by Forrester Research that enhances a company's technology decision-making processes and assists vendors in communicating the value proposition of their products and services to clients. The TEI methodology helps companies demonstrate, justify, and realize the tangible value of IT initiatives to both senior management and other key business stakeholders.

[2] Source: "The Total Economic Impact™ Of Mixed Reality Using Microsoft HoloLens 2," a commissioned study conducted by Forrester Consulting on behalf of Microsoft, November 2021.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