Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations

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Purpose

This document is prepared by Strategy Analytics, on behalf of the AREA, to illustrate the steps of an analyst or project leader when estimating the Return on Investment (ROI) of AR technology for a maintenance and repair operation (MRO) at a fictitious manufacturing company.

This resource is made publicly available to anyone seeking to perform a comprehensive ROI study in isolation or as part of a digital transformation strategic plan. It is provided by the members of the AREA at no cost to the ecosystem of Augmented Reality technology providers, customers of AR-enabled solutions and others participating the advancement of AR adoption. The purpose is to increase understanding among stakeholders of procedures and variables to consider when measuring AR ROI. With deeper understanding across different ecosystem segments and participants, collaboration and communications towards the measurement of AR ROI improve.

The calculations in this case study make use of the AREA Enterprise ROI Calculator. The AREA ROI Calculator is a working model made available exclusively to AREA members for calculating their ROI accurately and systematically.

An accompanying AREA member exclusive report provides insights on the mega-trends that are impacting ROI analysis on technology investments, identifies how ROI analysis on technologies that span information technologies and operation technologies is different from evaluating ROI on more traditional, capitalized IT investments, and then outlines the best practices shaping successful ROI analysis.

To find out about joining the AREA, these reports and other member benefits, please visit http://thearea.org and/or contact its Executive Director, Mark Sage.

Statement of the Challenge

For a wide variety of companies, any failure of equipment translates directly into lost revenue and opportunity costs. If the equipment in one part of a chain is down, other investments are unproductive.

In many industries, there are complex procedures for diagnosing potential or urgent operational issues, maintaining valuable equipment and repairing equipment that fails. Since the industrial revolution, the trend has been for equipment to be increasingly specialized and, in the past decades, requiring extensive training for employees to perform procedures requiring dozens or even hundreds of steps, in sequence and with highly specialized tools.

Some maintenance and repair procedures are only sparsely or poorly documented. Others have documentation that is so extensive that it requires one or more databases and technical communication systems to convey to the employee.

To ensure that operations run smoothly, without error and a high degree of safety, companies and their suppliers are seeking to use new technological systems. Many modern industrial systems are connected by networks to diagnostic systems that are continually assessing performance and even, in some cases, anticipating the need for maintenance and repair. In some cases, if the employee on site is untrained or inexperienced, an expert can travel to perform the maintenance and repair or to assist through telephone or remote visual conferencing systems.

However, any delay in repair can be costly and expertise is unevenly distributed so, the optimal scenarios are those in which the employee on site obtains all relevant information in real time and in context for the tasks, in sequence and with high precision.

Case Study of an MRO Deployment

This report provides a fictitious case of an AR-enabled Maintenance Repair Operations (MRO) application deployed by a fictitious healthcare services company, to illustrate the preparation of an ROI analysis. The company manufactures and sells instrument-sterilization equipment to healthcare facilities. As a value-added service, the company also provides contract maintenance services for the equipment. The company works with hundreds of healthcare providers, and each customer may have from one to several dozen sterilizers depending on the size and number of facilities that they operate. The company has ten service technicians that travel to customer sites to service and repair the sterilizers at the customer location.

The company is piloting the use of AR wearables for use by service technicians in diagnosis, maintenance, and repair of these machines.

Step One: Prepare the Business Case

Companies will typically analyze the costs and benefits of the technology before a pilot. Often informal, this provides the financial and operational objectives of the pilot. This analysis is often offered as free of charge by technology suppliers but companies should perform an independent cost/benefit analysis to ensure completeness.

It is important to note that effective ROI analyses require any and all "benefits" to be translated into the corresponding cash flows generated by the solution. For example, where an AR wearable display is used for a MRO solution, or when it is used to replace service and instruction manuals in manufacturing or service applications. In these instances, the reduction in costs generates a savings or positive cash flow that should be calculated as such in the model.

Extending this idea to our fictitious example below, the benefit of an MRO deployment reduced the mean-time-to-repair by fifty-eight minutes or forty-five percent. The cash flows from this productivity improvement are calculated by estimating the time saved based on the user employee's fully loaded annual costs (wages plus the cost of paid benefits). It is important to calculate any other productivity savings that are realized from other indirect users of the solution (e.g., managers who have reduced the time needed for quality checks or audits; sales or administration who have time savings due to the automated submission of open and closed maintenance orders.)

It becomes more challenging to estimate cash flows when one of the benefits is increased revenues, for example, when AR is used in virtual product demonstrations for sales and marketing teams. Or when in our fictitious solution, the company also believes that customer churn is positively impacted (reduced) due to the much higher efficiency they realize due to the MRO solution.

While there may be positive cash flow from improved productivity, there may be potential increase in top-line revenues and resulting profits due to the potential to sell more products/services to new customers or to satisfied, existing customers. This can be a difficult, subjective estimate. Some companies have completed formal studies on customer satisfaction and churn to more accurately estimate the impact and drivers of improved customer satisfaction, and if possible, these existing metrics should be utilized. In instances where satisfaction has not been evaluated, all team members, including finance and high-level decision makers should be engaged in identifying and calculating this impact to get buy-in on the results.

These benefits can also be evaluated formally within a pilot deployment. In our fictitious case study, the company conducted a six-month pilot and the benefits of the AR-enabled MRO pilot are provided in the following section.

Calculating Productivity Improvements

The company conducted a time and motion study with five of its maintenance technicians. The company also conducted a time/efficiency study of the related tasks in order processing required by the operations manager, as well as the order processing tasks of one of the sales/customer service team. The studies revealed time savings for maintenance technicians as compiled in the table below.

Task	Average time required (mins.)	Average time saved (mins.)
Notification of maintenance order	5	4
Drive to location	30	-
Inspect machine	40	20
Identify fault & diagnose solution	15	10
Perform repair procedure	30	15
Notify procedure complete	10	9
Total average time	**130**	**58**

Table 1. MRO Sample Time Study Findings (Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)

The company also identified that the service manager at dispatch would save an average of sixty minutes per day from the use of the application, which is the average amount of time she spends discussing and diagnosing repairs via telephone with technicians that are making repairs on the customer's site.

A customer service representative will also realize productivity improvements on average of 50 minutes per day from the application. Previously, repair orders were e-mailed to the person who initiated and completed the repairs. In the new AR MRO application, when the repair is complete the application will automatically generate a completion order and transmit it to the CRM platform, eliminating the need for the service rep to create and manage open and closed maintenance

orders.

The total benefit from improved productivity due to the MRO application is summarized below:

	Annual amount	
	Time saved (hrs.)	Financial Benefit
AR user/employee	2465.0	€ 25,756
Manager	255.0	€ 6,813
Other employees	212.5	€ 3,111
Total Productivity Benefit	**2932.5**	**€ 35,680**

Table 2. Benefit from Increased Productivity with IoT and AR-enabled solution (Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)

Reduced Costs: Hardware, Software & Services

There are also improvements to the company's bottom line as a result of reductions due to the elimination of hardware and/or software that was utilized in the legacy MRO process but is no longer needed for the AR-enabled deployment. This includes costs of equipment and all third-party services that were required to maintain or manage that equipment.

In our fictitious example, the company used five sterilizing machines as "loaners" for customers to use when repairs required more than one business day to complete. In addition, it had a contract agreement with a third-party company for maintenance services when the work flow exceeded the capacity of its ten technicians. The company expects to be able to eliminate this contract when the MRO application is deployed due to the higher on-site effectiveness of its maintenance staff. The company estimates that it will be able to eliminate the need for two of the five loaner machines and will write off the remaining depreciated value of these machines. In the legacy solution the company utilized a dated software application for fielding and managing orders and request for parts when needed for repairs. This software will also be eliminated as will the annual maintenance/upgrade costs associated with it. The benefits from the elimination of these annual costs are shown in the table below.

	Annual Cost Savings
Maintenance services contract eliminated by using the AR solution	€ 37,565
Hardware costs (remaining value) eliminated by using the AR solution	€ 28,770
Software maintenance costs eliminated by using the AR solution	€ 15,600
Total Benefit from Reduced Costs	**€ 81,935**

Table 3. Hardware, Software & Services Cost Savings (Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)

Increased Profits

The estimated increases in sales and resulting profits can have a significant impact on the results of the ROI analysis. As mentioned earlier there are many factors that create or influence a customer's purchase decision, and it is difficult to gauge the relative impact that an improvement in one of these factors will have on its own. Therefore, it is important for project leaders to:

1. Utilize formal studies that have been completed previously at a corporate or unit level. Many companies have scrutinized the impact and drivers of churn and customer satisfaction and as such have existing metrics to use to estimate the impact on sales or profitability when churn is reduced or satisfaction is increased by some percentage. Estimating the extent of the impact may still be an objective exercise, but being able to use a pre-calculated metric for measuring that impact can formalize the buy-in of the results especially for finance and executive level decision makers.

2. When existing metrics on satisfaction and churn are not available, project leads should develop estimates in close collaboration with senior management and decision makers that include finance and accounting. Capturing their guidance in early stages of the effort on what are acceptable estimates will guide planning and reduce the potential for conflicts at the end-evaluation of the ROI results.

In our example, the MRO solution will reduce the average on-site time needed to repair these machines for its customers by forty-five percent and this factor is in the estimation of the project team the key factor in improving satisfaction and reducing churn.

The company has experienced an annual customer churn rate of 2.5% of total sales. Realizing that there are many factors that contribute to customer churn, the company made conservative estimates of the impact of this forty-five percent reduction in the mean-time-to-repair for its customers. Via consultation with the finance and management team members within the project leadership team, the project leader gained consensus to use an estimate of a 20% reduction in churn, from 2.5% to 2%, which yielded increased annual profits as shown below:

Item	Annual Amount

Average annual company equipment sales	€ 5,480,000.00
Sales generated by reduction in churn	€ 27,400.00
Average increased annual net profit margin	€ 4,795.00

Table 4. Increased Sales & Profits *(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)*

Reduced Inventory

Many companies utilizing MRO solutions maintain an inventory of assemblies, motors or other parts to ensure availability of common components that can improve efficiency and reduce mean-time-to-repair. AR solutions can reduce these costs due to the higher on-site efficiency due to more accurate diagnosis and repair enabled by the application. Also, AR MRO solutions that are integrated with ERP or fulfillment systems can enable just-in-time processes for ordering replacement parts that can be drop-shipped to a customer location and effectively eliminate the need for inventory. These annual savings are reflected in the reduced inventory and should include the cost of the capital deployed annually to purchase it.

In our example, the MRO solution is being integrated with these systems, and the project leader estimates that the company can eliminate 90% of its annual inventory of parts and components. will reduce the average on-site time needed to repair these machines for its customers by forty-five percent and this factor is in the estimation of the project team the key factor in improving satisfaction and reducing churn. The table below provides the annual savings due to reductions in parts and component inventory:

Average annual inventory value	€ 19,000
Current cost of capital	7.0%
Percentage that current inventory can be reduced through use of the AR solution	90.0%
Total annual benefit from inventory reduction	**€ 1,197**

Table 5. Annual Benefit from Reduced Inventory *(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)*

Reduced Audit/Accounting Costs

The use of AR to service and maintain hard assets (operating machinery/equipment, etc.) or to automate operational processes can reduce the amount of time and resources needed to conduct accounting-based audits of processes and activity-based costings, thereby directly reduce auditing and accounting costs.

In the case study, these accounting costs were reduced by twenty-five percent due to the automation of the process using IoT-enabled connectivity and the integration of the maintenance order processing with ERP and fulfillment systems, as shown in the table below.

Amount spent annually on audits	€ 19,900
The estimated percentage reduction in audit costs due to using the AR solution	25.0%
Total Annual Benefit From Reduced Audit Costs	**€ 4,975**

Table 6. Annual Benefit from Reduced Accounting/Audit Costs *(Source: the AREA Case Study –*
ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)

Step Two: Estimating AR Solution Costs

The analysis in this section explains the typical costs of an AR solution and how these costs can be allocated or considered by the project manager. Note that all cost estimates provided here are for illustration purposes only and are not meant to reflect or approximate actual market prices.

Software & Cloud

The software costs typically include the initial license fees as well as the ongoing costs (annualized) for the subscription license(s) & maintenance fees. Other costs may include support software, or other software for devices or networks.

The need for cloud-enablement depends on the AR solution and factors driven by a company's larger IT strategy. AR solutions can run on the corporate network and do not always require or need cloud connectivity.

In either case, the costs associated with cloud-enablement are not included in the ROI analysis. Leading companies consider cloud-enablement a "strategic enabler" of new technologies and applications, which they can deploy as needed across business units These firms account for the costs of cloud enablement in one of two ways: 1) removed from the ROI analysis of the AR deployment and included in corporate level IT budgets, or 2) allocated using an estimated proportional allocation of the costs across all units that utilize it.

For companies without a digital strategy or not actively utilizing cloud-based solutions, the cloud-enablement costs (if allocated 100% to the AR solution) can significantly reduce ROI and negatively impact the resulting analysis. It is strongly recommended that these companies consider the role of cloud in a strategic context and plan for its use in applications in the future to limit the impact of these costs both on the AR application and other technology deployments.

In our case study example, the organization has chosen to forego the incremental costs required to cloud-enable the solution and will instead account for these costs at the corporate level.

In our case study example the company realized the following software costs:

Cost of software licenses	€ 74,999
Cloud-enablement costs	€ 0
Annual maintenance fees	€ 4,999
Total Annual Software Costs	**€ 79,998**

Table 7. AR Software Costs *(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)*

Hardware for AR Visualization

AR hardware costs include the cost of the devices (glasses or tablets), network equipment like gateways and routers, and servers that might be required to support the application. In some cases, additional hardware may also be required as part of the deployment for security or integration with other business systems.

In our case study example the company realized the hardware costs shown in the table below.

Headset/glasses costs (6 pair for €1000/ea.)	€ 6,000
Additional network infrastructure costs (gateways, routers, servers)	€ 12,999
Additional hardware or equipment costs	€ 1,299
Annual hardware maintenance fees	€ 4,999
Total Annual Software Costs	**€ 25,297**

Table 8. Hardware Costs *(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)*

Capitalizing versus Expensing

Organizations will capitalize asset purchases to delay the recognition of those expenses when purchasing assets with a long lifecycle (e.g., heavy machinery, plant equipment, etc.).

Capitalizing these asset costs and then depreciating them over time affords smoother streams of reported income versus the more variable reported incomes associated with expensing, and companies that capitalize costs will also show higher net cash flows in the earlier years than companies that expense these costs. Companies expensing costs will have higher cash flows in the later years.

In our case study, the company has chosen to expense the hardware and software costs for this deployment, and this choice will be reflected in the "expensed" solution costs in the table on page sixteen.

Labor Costs

Labor costs include the time devoted to the evaluation, planning, and deployment of the AR solution by company staff and management as well as the time required for initial and on-going training. This can also include costs associated with the closure or suspension of processes during installation and testing, as well as time spent by users and staff in other business units that are affected during the suspension of processes due to system integration.

As when calculating productivity improvements, project leads should be careful to use labor cost estimates that reflect the average level of pay for each worker in the pilot. Project leaders should also be sure to use loaded labor costs that include not just wage but also the cost of benefits paid to the worker.

Project leads should anticipate that costs related to future training costs that will be necessary for new users due to turnover. They should also allocate costs for time and resources that will be spent for the ongoing management of the AR solution. These are sometimes hidden or difficult to identify, so project leaders should look closely for all staff and management in direct and indirect contact with the application.

In the case study, the company estimated labor costs for the MRO deployment as shown below:

Deployment labor costs	€ 3,690
Training costs	€ 1,097
Ongoing annual training	€ 686
Integration costs	€ 3,731
Total Labor Costs	**€ 9,205**

Table 9. AR MRO Labor Deployment Costs (Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)

Consulting & Professional Services

Consulting and professional services are utilized for application development, training, deployment, & systems integration. These are services provided by contractors or suppliers and would reflect only services costs (hardware/software costs are accounted for separately.)

The costs for content adaptation (preparation of digital manuals, component lists, products and machinery images, etc.) necessary for the AR solution should also be accounted for here. These costs can be significant relative to the size of the AR application itself, and companies need to carefully consider how to account for these costs.

If the content can be leveraged in other applications or processes or can be used as the basis for new technology or applications, leading companies will consider all or part of these costs as

corporate IT costs, thus eliminating all or part of these costs from the AR-specific ROI analysis. As with cloud-enablement costs, project leaders should consider their company's larger digital strategy and use that as a basis to determine how much of these costs are included in the AR project budget.

In our case study, the company has decided that it can use the digital content in other manufacturing and operational processes in the future, and as such will consider in the ROI analysis only twenty-five percent of the total costs of content adaptation of €174,000. This equates to €43,500.

Consulting Services - installation & training	€ 24,999
Consulting Services - content adaptation	€ 43,500
Consulting Services - integration	€ 0
Total Costs, Consulting & Third Party Services	**€ 68,499**

Table 10. Consulting & Third-Party Services Costs *(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)*

Financial Metrics

Accurate estimation of the cash flows from the investment requires adjustments for borrowing costs and taxes. Borrowing costs, commonly referred to as the cost of capital, are the interest the company pays to borrow or finance asset purchases. Interest will accrue when costs are capitalized, so project managers need to estimate these costs accurately. These costs can range upward from five to seven percent or more depending on market conditions. Project leads should confirm with their finance team to ensure that capital cost estimates are reflected accurately in the ROI assessment.

Corporate tax rates are also necessary for ROI analysis to calculate after-tax cash flows. These rates vary significantly depending on the country, and in some countries, corporations are also required to pay additional surcharges or municipal taxes in addition to federal taxes. Project leaders should confirm with the finance team to ensure that the correct tax rates are used for the analysis.

The type and length of depreciation method will also impact cash flows. There are several allowable depreciation methods that can be used to allocate expenses differently over the period or to calculate proportional depreciation expenses. For clarity in the results, we suggest utilizing the straight-line method of depreciation which allocates the costs of the AR solution over its useful life. Project leaders must select the period or useful life over which to spread these costs, which can range from three to seven years or more depending on the situation. Financial team members can provide corporate guidance to project leaders on the duration to use. In our modeling, we assume that most AR solutions are depreciated over a three to seven- year period.

In our case study, the company has a cost of capital of seven percent, a corporate tax rate of thirty-nine percent. Since it is not capitalizing any of the costs of the deployment, depreciation is not applicable.

The financial metrics of the company in our case study are provided in the top table of the ROI analysis in the following section.
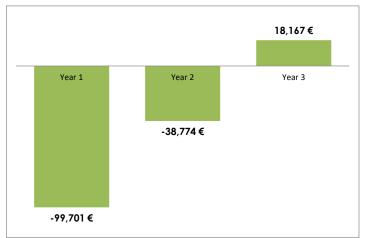
Step Three: Analyzing Results & Conclusions

Using the calculated AR MRO benefits, estimated costs and financial metrics outlined in the previous sections, the AR-enabled MRO deployment in our case study provides:

- A forty-two percent annual rate of return on the initial investment;
- An annual average net benefit of nearly €129,000;
- A payback period of three years and forty-seven days.

Figure 1. Cumulative Net Benefit from introducing AR-assisted MRO *(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)*

When considering typical investments in IT infrastructure and software, acceptable minimum threshold rates of return on investment range from ten percent to fifteen percent depending on the industry. Average life cycles used to calculate the return on these IT investments have fallen over the last decade from five to seven years to an average of three to five years, depending on the industry.

The return on investment of our case study example is an outstanding rate of return. That said, It is important to note that ROI analysis is fluid and in its nature can vary based on the accounting principles and financial metrics used by the organization. Actual calculated returns can vary, sometimes significant, depending on the methods used to quantify benefits and allocate costs, and the overarching corporate strategies companies use for allocating strategic costs like IoT connectivity, cloud enablement, and content adaptation costs associated with the application.

These factors combine to make it challenging to evaluate the return on investment of an early-stage technology like AR. However, it is important for project leaders to undertake ROI analysis on their AR investment to enable and justify sound technology spending practices that will aid in decision making and to enable the organization to accurately measure and thus accrue benefits over the long term from their AR investment.

Appendix: Summary of Case Study Metrics

ROI Analysis	Year 0	Year 1	Year 2	Year 3	Totals
Net cash flow before taxes	-€ 164,893	€ 114,166	€ 114,166	€ 114,166	€ 342,498
Net cash flow after taxes	-€ 164,893	€ 69,756	€ 69,756	€ 69,756	€ 44,373
Annual ROI		**42.3%**	**42.3%**	**42.3%**	
Net Present Value (NPV)	-€ 164,893	-€ 99,701	-€ 38,774	€ 18,167	€ 56,925
Cumulative Net Cash Flow	-€ 164,893	-€ 95,138	-€ 25,382	€ 44,373	
Payback period in years					3.40

Benefits	Year 0	Year 1	Year 2	Year 3	Totals
User Productivity Improvements	€ 0	€ 35,680	€ 35,680	€ 35,680	€ 107,039
Increased Profits	€ 0	€ 4,795	€ 4,795	€ 4,795	€ 14,385
Reduced Hardware & Software Costs	€ 0	€ 81,935	€ 81,935	€ 81,935	€ 245,805
Reduced Audit Costs	€ 0	€ 4,975	€ 4,975	€ 4,975	€ 14,925
Reduced Inventory Carrying Costs	€ 0	€ 1,197	€ 1,197	€ 1,197	€ 3,591
Other Direct Cost Savings	€ 0	€ 0	€ 0	€ 0	€ 0
Other Indirect Benefits	€ 0	€ 0	€ 0	€ 0	€ 0
Total Benefits	**€ 0**	**€ 128,582**	**€ 128,582**	**€ 128,582**	**€ 385,745**

Costs - Operational Expenses	Year 0	Year 1	Year 2	Year 3	Totals
Software	$74,999	€ 4,999	€ 4,999	€ 4,999	€ 14,997
Hardware	€ 20,298	€ 4,999	€ 4,999	€ 4,999	€ 14,997
Labor	€ 1,097	€ 4,417	€ 4,417	€ 4,417	€ 13,252
Consulting & Professional Services	€ 68,499	€ 0	€ 0	€ 0	€ 0
Total Operational Expenses	**€ 164,893**	**€ 14,415**	**€ 14,415**	**€ 14,415**	**€ 43,246**

Costs - Capitalized Assets	Year 0	Year 1	Year 2	Year 3	Totals
Software	$0	€ 0	€ 0	€ 0	€ 0
Hardware	€ 0	€ 0	€ 0	€ 0	€ 0
Labor	€ 0	€ 0	€ 0	€ 0	€ 0
Consulting & Professional Services	€ 0	€ 0	€ 0	€ 0	€ 0
Total Capitalized Costs	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**

Depreciation Schedule - Capitalized Assets	Year 0	Year 1	Year 2	Year 3	Totals
Software	$0	€ 0	€ 0	€ 0	€ 0
Hardware	€ 0	€ 0	€ 0	€ 0	€ 0
Labor	€ 0	€ 0	€ 0	€ 0	€ 0
Consulting & Professional Services	€ 0	€ 0	€ 0	€ 0	€ 0
Annual Depreciation Total	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**

(Source: the AREA Case Study – ROI Analysis for AR Use in Maintenance & Repair Operations, 2017)