WHITE PAPER: ENTERPRISE MAINTENANCE WITH AUGMENTED REALITY

THE WORKPLACE OF THE FUTURE
EMPIRICAL EVIDENCE GATHERED FROM COMPANIES IN THE U.S AND CANADA SHOWS THAT COMPANIES THAT REDUCE TOTAL MANUFACTURING CYCLE TIME BY 75% WILL DOUBLE PRODUCTIVITY, REDUCE THE BREAK-EVEN POINT OF A FACILITY BY 20%, GROW AT THREE TIMES THE INDUSTRY AVERAGE, AND HAVE TWO TIMES THE INDUSTRY AVERAGE MARGIN.

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ABSTRACT
This white paper outlines the 'how and why' of industrial maintenance with Augmented and Mixed Reality. It will explain the four key areas in which maintenance occurs in industry and how these tasks can be optimised with Augmented Reality. Finally, this paper will categorize the best devices and software that can be used to incorporate AR operations into business scenarios at a low cost with high impact.

BOX FACTS:

92% of industry 4.0 suppliers and 74% of manufacturers expect industry 4.0 to have an impact on their business model.

75% companies that reduce total manufacturing cycle time by 75% will double productivity.

98% expect to increase efficiency with digital technologies like integrated MES, predictive maintenance or augmented reality solutions.

43% A study by Forbes reveals that for 43% of the interviewed manufacturers exploiting opportunities to grow their business has a high priority.

62% of automotive companies will make huge investments into IoT.

Manufacturers are looking to globalize best practices to improve quality, increase productivity and control operational costs.

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AUGMENTED AND MIXED REALITY MERGE THE DIGITAL WORLD WITH THE REAL AND ALLOWS YOU TO PLACE DIGITAL INFORMATION INTO THE WORLD AROUND YOU. AUGMENTED AND MIXED REALITY APPLICATIONS CAN BE USED FOR VISUAL GUIDANCE ON SMART PHONES, TABLETS AND SMART GLASSES TO SIMPLIFY PRODUCTION, TRAINING, MAINTENANCE AND REPAIR.
INTRODUCTION
At some point in time machinery will fail. In most cases this will be caused by human error, system upsets or component failure upstream or downstream that can cause moving parts to run into a failure. According to the data, these causes accounted for 70 to 80 percent of all failures vii. Regardless of industry, being automotive, aviation, steel industries, paper industries or and other heavy industries it is imperative to get things running as quickly as possible.

The impact of an industrial downtime is staggering. On the one hand costs increase by 5 to 10 percent viii, but the true cost of a machine breakdown has been estimated as between 4 to 15 times the maintenance costs. For every second production is down, the company is losing money: deadlines may be missed, impacting the rest of the supply chain, risks penalties and even customers viii. Not only this, but if downtimes occur too often or at a particularly bad time during the middle of the week, this bad experience could easily shake a customer and damage the company’s reputation for delivering value ix.

It is easy to see why downtime is a dreaded aspect of industry, and why maintenance practices need to be a fluid process to get things up and running. Enterprise are therefore spending large amounts into maintenance, and it has become a large part of any industry and can represent between 15 and 60 percent of total costs. In the United States, industries spend more than $200 billion each year on maintenance x.

COSTS DURING DOWNTIMES INCREASE BY 5 – 10%
Stratus viii

THE TRUE COST OF A MACHINE BREAKDOWN HAS BEEN ESTIMATED AS BETWEEN 4 TO 15 TIMES THE MAINTENANCE COSTS ix.

A single minute of downtime in the automotive sector can cost OEMs up to $22,000 Business Insider viii

Recent surveys have shown that there is a need for better maintenance implementation. Improper and unnecessary maintenance actions make up almost 33% of maintenance cost x.
DATA BANKS, IOT AND TECH: THE TOOLS FOR PROCESS OPTIMIZATION

More staggering than the costs involved in industrial maintenance are the banks of data readily available in most companies to dramatically improve maintenance and repair processes. Correctly harnessed, this data has the power to simplify complex processes on the micro level to impact production on the macro. For example, a simple tweak to a standardized maintenance procedure on the production floor could prevent a complete stop to multiple operations.

Industry 4.0 is no longer a catchy buzz word nor trend, it has become a do-or-die movement for automatizing and exchanging data throughout the modern industrial sector. Today 93% of companies identify challenges with implementing and maintaining information systems and operational infrastructures\(^{vi}\). The IoT tools now readily available open the door for enterprise to easily collect operational data and optimise these processes. Augmented and Mixed Reality are the next generation technology that allows employees and customers to visualize this collected data in daily tasks in working environments. Harnessing this data will be a key to user experience and those manufacturers that are not able to make the leap will find themselves largely irrelevant in the next 5 to 7 years because people will increasingly look for the value beyond the product\(^{v}\).

With ever growing mechanisms and technologies for IOT entering the enterprise market, 80% of companies already expect Industry 4.0 to impact their business model. In the German manufacturing sector alone, BCG estimates that Industry 4.0 can drive productivity gains of 5 to 8 percent on total manufacturing costs over ten years,

\[4.0\]
\[5-8\%\]
\[+€150\]

**INDUSTRY 4.0**

Across industries, an average of 74 percent of a company’s information technology budget is spent on operational expenses; that is, maintaining legacy applications and infrastructure (otherwise known as “keeping the lights on”).
While IoT tools collect all the precious operational data, Augmented and Mixed Reality are two of the key Industry 4.0 technologies for visualizing the data at worker level at ground zero. Both Augmented and Mixed Reality are gaining swift traction amongst many business leaders. A 2016 survey not only discovered that 39% of respondents were already using AR in their organization, but a staggering 67% of those not using AR were considering its implementation.

There are countless cases of AR being used in manufacturing and Google even just re-released the Glass to meet the demand and to catch up with the popularity of the HoloLens for enterprise cases. A Goldman Sachs study estimated 6 million users of AR in the field of engineering at a value of $4.7 billion.

Meanwhile, in 2016 IDC found that there are already around 111,000 AR headsets in operation in the commercial segment and projected more than 20 million by 2021 - that’s a 184% Compound Annual Growth Rate, giving an 83% AR headset market share in 2021 in commercial segment.

**COMPARISON OF THOSE WHO ARE CONSIDERING ADOPTION OF AR TECHNOLOGY VS. VR TECHNOLOGY**

<table>
<thead>
<tr>
<th>Category</th>
<th>AR</th>
<th>VR</th>
</tr>
</thead>
<tbody>
<tr>
<td>We are considering it in the next 12 months</td>
<td>13%</td>
<td>20%</td>
</tr>
<tr>
<td>We are considering it in the next 3 years</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>It is on our strategic roadmap - no deadline yet</td>
<td>25%</td>
<td>37%</td>
</tr>
<tr>
<td>We are not considering it</td>
<td>34%</td>
<td>53%</td>
</tr>
</tbody>
</table>

No. of respondents for VR technology: 114
No. of respondents for AR technology: 101
Source: zdnet.com

**USE OF AR TECHNOLOGY BY RESPONDENTS’ ORGANIZATION**

- 61% don’t use any AR technology
- 19% as part of the products they make
- 12% in simulation exercises
- 8% in employee testing/training
- 8% in computer modelling activities
- 8% in the sales process
- 8% in GPS and GIS applications
- 7% in other applications
- 5% in computer analytics

No. of respondents: 165
Source: zdnet.com
FIELDS OF APPLICATION: AUGMENTED REALITY IN MAINTENANCE

INSPECTION & PREDICTIVE MAINTENANCE – The first step to effective maintenance processes and optimal outputs is to ensure a smoothly running ship is always in operation. Simply put, avoid the breakdown before it occurs. Unexpected downtimes or breakages will ultimately stop the flow and, in most cases, have huge cost repercussions – a single minute of downtime in the automotive sector can cost OEMs up to $22,000.5. Because of this, the need for eliminating catastrophic breakdowns and unnecessary maintenance costs in production processes has and will continue to drive the adoption of condition monitoring solutions across several industries.16

The ability to use existing data to predict when maintenance will have to occur is a huge game changer. Using smart, connected technologies that merge the real working environment with digital information has the power to reduce the time required to plan maintenance by 20-50%, increase equipment uptime and availability by 10-20%, and reduce overall maintenance costs by 5-10%.15 Augmented Reality in operations allows workers to visualize this data directly on machinery and equipment in an understandable way. This not only the time needed for specialist technicians to get the job done, but increasing yearly output. The downtime reduction and output increase is so significant that recent analysis suggests that the market for predictive maintenance applications is poised to grow $10.9 billion by 2022, a 39% annual growth rate.18

50% reduction in repair cycle time for defects
Using Augmented Reality to visualize data, a company in a recent Deloitte study saw a 50% reduction in repair cycle time for defects and estimated savings of $500,000 in a single product line through reduced downtime.19

27% reduced costs, 10% increase energy efficiency, increased uptime
McKinsey monitored a company where maintenance costs accounted for 25 percent of operating expenses. Using predictive maintenance, reduced costs by up to 27 percent while increasing reliability and uptime. Advanced analytics for energy and yield also has the potential to increase energy efficiency by as much as 10 percent.20

Reduced inspection times from 3 weeks to 3 days
Almost 1000 Airbus employees use SART (Smart Augmented Reality Tool) every day for various fields. In one daily use, technicians use Augmented Reality to inspect a bracket installation in fuselage assembly using a tablet’s camera to superimposes a virtual image of the correct fitting over the actual as-built product. According to Airbus, the introduction of AR has reduced inspection times in some cases from 3 weeks to 3 days.21

Recent studies also show that unplanned downtime costs industrial manufacturers an estimated $50 billion each year. Deloitte

A Rath & Strong, management consultant has proven that it is physically possible to reduce cycle time by 75% in a manufacturing area or product line in as little as 3 months, and that it can routinely be done in 6 months. Two major categories are: Predictability and Flow. Both of them can be improved by AR. Rath & Strong

Reduced inspection times from 3 weeks to 3 days

WEEK 1       WEEK 2       WEEK 3

AR

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RE'FLEKT, MARCH 2018
MAINTENANCE & REPAIRS (IN-HOUSE) – while predictive maintenance can considerably reduce repair cycle times and reduce the risk of downtimes, it cannot eliminate downtimes or stoppages completely. When the downtime occurs, there is simply no chance to avoid maintenance and repair processes. The trick is to get things up and running as quickly as possible. In many cases the downtime is a result of some sort of machine part breakage that requires replacement. It could be that there is no specialist for this machinery in-house or that the replacement procedure simply hasn’t been done before and is unfamiliar. In both cases a decision needs to be made:

• Call a specialist technician and attempt to perform the procedure over the phone in a usually noisy environment. Or wait for the technician to arrive and fix the problem (which could take hours or days depending on how much your company is prepared to spend)
• Do it yourself (DIY). First find the manual for the corresponding machine in the company archive. Find the corresponding information for the part believed to be causing the downtime. Decipher the 2D information and attempt to solve the problem.

In both scenarios, the problem will be fixed. It is simply a question of how much time was needed to do so and how much that time cost. Immediate specialist teams sent out by the supplier keep downtime costs down but are extremely expensive. On the other hand, this cost is avoided with the DIY strategy but could have devastating downtime costs or may cause further breakages.

Augmented Reality empowers industry by making the DIY option plausible. Simply by updating the 2D user manual into 3D instructions allows the in-house technician to immediately find the correct information and solve the problem with intuitive 3D step-by-step instructions projected directly onto the machine. Whether using AR enabled smartphones or tablets, monocular smartglasses such as the Google Glass or Vuzix or high end smart glasses like the Epsion Movario, ODG R8 or Microsoft Hololens – Augmented Reality assists workers to perform maintenance and repairs quicker, safer and more efficiently.

Perform tasks 56% faster
The Columbia university researchers worked with mechanics from the U.S Marine Corps to measure the benefits of using an AR headset when performing repairs to a light armoured vehicle. The mechanics using the AR system located and started repair tasks 56% faster, on average, than when wearing the untracked headset, and 47% faster than when using just a stationary computer screen.

Reduce costs and schedules by 95%
Newport News Shipbuilding, who built lead ship of US Navy supercarrier, said that implementing AR on their work means promised project. NNS also said that they conducted 36 hours of inspection in 90 minutes which is about 95% cost and schedule cuts.

SIMPLY BY UPDATING THE 2D USER MANUAL INTO 3D INSTRUCTIONS ALLOWS THE IN-HOUSE TECHNICIAN TO IMMEDIATELY FIND THE CORRECT INFORMATION AND SOLVE THE PROBLEM WITH INTUITIVE 3D STEP-BY-STEP INSTRUCTIONS PROJECTED DIRECTLY ONTO THE MACHINE.
MAINTENANCE & REPAIRS (AS A SERVICE) – while reducing downtimes and keeping operations running smoothly in-house with Augmented Reality is one side of the coin, there are also plenty of external business models and cases that can profit from more efficient maintenance procedures. For example, in 2016 the European Maintenance, Repair and Overhaul (MRO) distribution market was valued at USD 89.0 billion whilst the North American industrial maintenance services market was valued at USD 186 billion. And these markets are only expanding further, with projections of the North American market to grow at a compound annual growth rate of 4% during the next years.

Whether for automotive, agriculture, healthcare, aviation or any of the other heavy industries, it is common for companies to want to rely on the supplier or external services for premium support. Because of this, there is a huge demand for maintenance service providers. By using Augmented Reality technology these providers are streamlining their repair processes and scaling the business more effectively with competitive prices.

A recent Mckinsey study found that Augmented Reality devices have the ability to improve the effectiveness of maintenance, repair, and security workers in these service environments. The economic impact is estimated to be $3 billion to $6 billion per year globally in 2025. Separately, analyzing IoT data to improve process could generate $1.5 billion to $4 billion of economic benefits. They estimate that by connecting these services to the Internet of Things could see total potential economic impact of $3.9 trillion to $11.1 trillion per year in 2025. These numbers clearly project that the combination of Augmented Reality and IoT data within enterprise environments can create powerful business tools with staggering economic benefits.

Companies such as Bosch are already utilizing Augmented Reality in their workshops to streamline automotive and industrial machinery processes for their customers. Augmented Reality work instructions allow Bosch technicians and mechanics to immediately access IoT data from the vehicle to see where malfunctions are and then pull the corresponding repair procedure for guided assistance. What’s more, this technology is also being used to create protocols from repair processes that can be sent onto the supplier about any work that has been done.
CUSTOMER SERVICE & SUPPORT – A major player in the MRO (Maintenance, Repair and Operations) support and services world are remote telephone solutions. While these services are commonly used in consumer markets, they are also widely used within industrial settings. However, over the phone services are often unable to clearly guide technicians through complex procedures and often require the additional use of handbook or technical documentation. Not to mention, these services are often experience extended wait times with recent studies finding that the standard target response time during business hours is two hours or less xxvii.

The latest developments in Augmented Reality hardware and software have opened up vast opportunities that dramatically strengthen the offerings of remote telephone support solutions. With these latest technological improvements, it is now possible to add Augmented Reality features to remote collaboration tools with live video support. For example, in the case of a downtime, a technician is now able to use a smartphone, tablet or smart glasses to video call technical experts. This expert can then explain how to maintain or fix the machinery in question by annotating or projecting 3D instructions into the technicians field of view and directly onto the machine. This eliminates the need to explain complex procedures without a visual guide or additional handbook materials to resolve the issue quickly and easily. Simply put, these new remote AR collaboration services simply the complex in a similar way to conventional AR solutions but have the added value of live human expert support on top.

Remote AR services are currently dominating industrial demands and development as they provide the all-round solution for a range of fields. Some companies such as ThyssenKrupp have already begun trialling these services with impressive results. For example, ThyssenKrupp are using Remote AR for training service requests ahead of the visit and getting hands-free remote holographic guidance when on site. They have found that these services reduce the average length of service calls by up to four times that of traditional services xxviii.
CHALLENGES, SOLUTION AND BENEFITS OF AR MAINTENANCE

With the AR market on the rise and plenty of industrial companies already implementing AR technology to their operational processes – the natural question to ask is... why?

For business owners aiming to achieve a maximum yield, efficiency is essential. Yet, as identified, maintenance costs are also unavoidably high. AR allows enterprises to streamline maintenance costs (and sometimes avoid them with predictive maintenance) and increase worker and machine efficiency through more effective processes. Expensive skilled technicians can be reduced and unskilled workers are given the knowledge to work on items previously outside of their jurisdiction. For many manufacturers, the wage bill is the biggest contributor to cost in the goods they make; it’s also one of the most difficult to control and optimize, yet with AR this is now possible.

AUTOMATION AND THE WORKING HOUR

McKinsey conducted a study that says: “Our data and analysis show that as of 2015, 478 billion of the 749 billion working hours (64 percent) spent on manufacturing-related activities globally were automatable with currently demonstrated technology. These 478 billion working hours represent the labor equivalent of 236 million out of 372 million full-time employees—$2.7 trillion out of $5.1 trillion of labor - that could be eliminated or repurposed, assuming that demonstrated technologies are adapted for use in individual cases and then adopted. These figures suggest that, even though manufacturing is one of the most highly automated industries globally, there is still significant automation potential within the four walls of manufacturing sites.”

MCKINSEY STUDY RESULTS

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<thead>
<tr>
<th>YEAR</th>
<th>AUTOMATED MANUFACTURING</th>
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<tbody>
<tr>
<td>2015</td>
<td>+ 64% WORKING HOURS</td>
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ENTERPRISE MAINTENANCE WITH AR
RE’FLEKT, MARCH 2018
## Augmented Reality Benefits

### Unreliable Equipment
Downtimes are the highest cost for most industrial companies and occur too often because of outdated, infrequent and long inspection processes.

### Efficient Inspection
Aviation style checklists guide technicians through inspection procedures with 3D visualizations. Completed inspection protocols are sent directly from the device to the central administration to ensure all machinery is constantly monitored.

### 20% Reduced Maintenance, 20% More Uptime
Reducing downtimes with predictive maintenance processes not only avoids expensive downtime and maintenance costs, but increases uptimes by up to 20%.

### Safety during Operations
Safety instructions often only appear in paper based manuals - long disregarded after first use. Injuries often occur to employees and customers unaware or ignoring safety regulations.

### Create a Safe Environment
Include safety instructions into AR procedures to ensure that they are not forgotten or ignored - ensuring that all processes are completed without any risks.

### Increased Safety
AR enables employees or customers to safely perform interactive, hands-on operations in environments and scenarios where safety was previously a concern.

### Demand for Expert Technicians
During downtimes or specialized processes, companies often require either external experts or time taken from experienced colleagues.

### Self Guided Operations
AR empowers employees and customers with self-guided procedures and enables ubiquitous, collaborative and situated operations.

### Reduced Expert Technician Costs
Reduce or eliminated the costs for expensive specialist technician callouts by empowering workers to avoid downtimes and complete operations themselves.

### Quality Assurance
Picking and packing as well as installation and assembly lines often lack the capability to accurately check and compare their processes with optimal-state guidelines.

### Real Time Comparison Checks
No need to find a manual or check a photo, AR places real time 3D visualisations of optimal conditions onto machinery and products to ensure that employees and customers always work within the necessary guidelines.

### Maximum Yield
Always seeing the correct product or machinery conditions reduces the risk of errors by up to 90% and ensures optimal conditions are always achieved to save time, money and efforts in other areas.

### Operational with Maintenance
Huge handbooks, lost information, outdated versions or simply information are too difficult to find and apply to operational repair and maintenance processes. Not to mention wasted costs on printing, materials and waste.

### Organized Data Where It Needs to Be
Repair and Maintenance data appears exactly where it needs to be on real objects without having to search.

### Save Time – By 50%
AR gets maintenance tasks completed faster. Processes can be picked up, visualized and used immediately at any time in the field.

### Outdated 2D Diagrams
For complex processes, 2D diagrams are unable to effectively display core tasks or be practically applied.

### 3D Instructional Data
3D AR visualizations on real world objects allow employees and customers to understand processes by being able to see the information as we see it in the real world... in 3D.

### Reduce Errors – By 90%
Precise visualizations of 3D data exactly in the correct position on real objects as well as procedures in any language ensures that employees and customers always understand their tasks.

### Inefficient Remote/Telephone Services
Outdated remote services do not connect technicians to immediate support, nor do they have the ability to clearly walk technicians through complex maintenance repairs over the phone.

### Live AR Remote Support
“See what I see” remote services allow customer support agents to see exactly what is happening, to overlay AR steps and annotations into the technician’s field of view and directly onto the item that needs to be repaired, and clearly guide technicians.

### Save Time and Money
Precise visualizations of 3D data exactly in the correct position on real objects as well as procedures in any language ensures that employees and customers always understand their tasks.
RE’FLEKT is a Munich based technology company that enables any business or industry to create their own in-house Augmented and Mixed Reality applications. By making AR and VR affordable and scalable for business, RE’FLEKT’s groundbreaking human-centered platforms empower anyone to simply infuse their industry knowledge into customized AR and MR solutions.

RE’FLEKT creates the workplace of the future for global players such as Atlas Copco/Leybold, Bosch, Hyperloop and Mercedes Benz and is recommended by leading analysts including ABI Research and experts in one simple click.

The RE’FLEKT Augmented Reality ecosystem for enterprises provides a powerful content creation platform and a remote expert solution to empower workers with flexible and customizable smart instructions on mobile devices and smart glasses – for increased efficiency and reduced errors. The content creation platform integrates into existing enterprise software and enables companies to easily convert existing CAD data and media content into Mixed Reality applications for maintenance, training and operations. The Remote Expert tool connects workers to immediate Augmented Reality support with dedicated experts in one simple click.

RE’FLEKT GmbH
AUGMENTED REALITY EXPERTS
www.re-flekt.com

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