What we are expecting from this presentation:

A. We want to inform you on the most important highlights from this topic

B. We need you to take the time to explore the presentation carefully and with a critical mind

C. We would like you to write down every comment or idea that emerges while reading this presentation

D. We exhort you to share with us a constructive feedback for further improvements

E. We invite you to dialog with us if you have any doubt or want to dive into some specific aspects
Augmented Reality
Augmented Reality & its Implementations
Global Market and Players
Value Chain
Levels of Technology Sophistication
Current Applications
Smart Glasses Augmented Reality Applications
Characteristics of using Augmented Reality for Maintenance
Pilot Stages & Business Case
Takeaways & Main Conclusions
Augmented Reality is a game-changing technology that enhances one’s current perception of reality

Augmented Reality (AR) definition

“The technology of combining real world images or video with computer-generated information or imagery. Augmenting refers to adding layers of digital content to the real world“

Implementations of AR Technology

<table>
<thead>
<tr>
<th>Mobile</th>
<th>Smart Glasses</th>
<th>Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superimposing a computer-generated image on a user's view of the real world through a screen such as that in a tablet or smartphone</td>
<td>Wearable computing devices that allow for the depiction of virtual objects in the subject’s field of view</td>
<td>Images are projected onto a physical object without the need for carrying an extra display and providing more than user viewing the images</td>
</tr>
</tbody>
</table>
The global AR market is expected to be worth $120 B USD by 2020, up from $10 B USD value in 2017. It is growing exponentially as technological improvements and content make it mainstream.

**Global AR Market Revenue Share (2020)**

A growing technology, the industrial AR market will reach USD $2.4 B by 2019, up from USD $247 M in 2014.

**The AR Ecosystem (Mobile & Smart Glasses)**

**Source:** Visual Capitalist. Virtual and Augmented Reality: They Players and the Game
Out of the three AR implementations, Mobile and Smart Glasses are dominant. The value chain for these technologies in the enterprise involves companies developing both hardware and software solutions.

The Augmented Reality Industry Value Chain

- AR software platforms and apps for mobile devices
- AR software for glasses displays
- AR glasses – product design & components assembly
- Transparent displays for AR glasses

Companies like INFINITY, UBiMAX, Google GLASS, and PLANAR are highlighted in the diagram.
## Levels of Sophistication

<table>
<thead>
<tr>
<th>1</th>
<th>Location-based AR</th>
<th>The AR app overlays relevant information on top of a real view, at the right place and time, using geolocation and data from back-end systems</th>
<th>Applications exist today and bring tangible benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Marker-based AR</td>
<td>The AR app scans markers such as QR codes to identify products and assets. Other markers can provide spatial references</td>
<td>Available today but most applications are in pilot testing</td>
</tr>
<tr>
<td>3</td>
<td>Markerless AR</td>
<td>The AR app builds a 3D representation of its environment, adapting in real-time to the user’s gaze and to surroundings. Parts are identified automatically and enriched with virtual information</td>
<td>Available today but most applications are in pilot testing</td>
</tr>
<tr>
<td>4</td>
<td>Enterprise AR</td>
<td>AR apps are widespread in factories and fully integrated with the Internet of Things. Continuous improvement is achieved thanks to gesture analysis and workers’ feedback</td>
<td>In 5 years it may be possible. It is the ideal AR application</td>
</tr>
</tbody>
</table>

Source: Tech Pro Research. Virtual and Augmented Reality in the enterprise: Cost factors, benefits, future plans
Mobile and Smart Glasses technology offer similar features. However, Smart Glasses are more suitable for factory floor usage as they allow for hands-free working.

<table>
<thead>
<tr>
<th>AR Technology</th>
<th>Battery life*</th>
<th>Price</th>
<th>Sensors</th>
<th>Connectivity</th>
<th>Security</th>
<th>Weight</th>
<th>Usability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 hours</td>
<td>USD $800 –</td>
<td>Proximity</td>
<td>Wi-fi</td>
<td>Encrypted</td>
<td>Around 80g</td>
<td>Hands-free</td>
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<tr>
<td></td>
<td></td>
<td>$3,000</td>
<td>Ambient light</td>
<td>Bluetooth</td>
<td>communication</td>
<td></td>
<td>Voice commands</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>GPS</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Head tracking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Compass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 hours</td>
<td>USD $350</td>
<td>Proximity</td>
<td>Wi-fi</td>
<td>Can encrypt</td>
<td>400g</td>
<td>One hand needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ambient light</td>
<td>Bluetooth</td>
<td>data</td>
<td></td>
<td>to hold the</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>GPS</td>
<td></td>
<td></td>
<td></td>
<td>device</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Compass</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

*Continuous usage
Current AR Applications for the Enterprise

**Visualizing Product Design**

Design augmentation allows to see the products being developed in the form of a life-sized virtual replica

Benefits:
- Realistic comparison with other existing products
- Accelerated timeline for evaluation and for soliciting feedback

**Manufacturing Space Design**

Users can add virtual machines, coming from CAD files, to visualize and propose a new factory layout

Benefits:
- Optimal space layout
- User can walk around and evaluate the proposed design from any angle

**Marketing**

Users can manipulate a digital object, show it to stakeholders and better understand the characteristics of the product they are developing

Benefits:
- Designers can get feedback directly from stakeholders
- The product can be shown in a real setting

*Source: Buntz B. 10 Killer Applications of the IoT and Augmented Reality*
As Smart Glasses AR technology continues to evolve, there are several indicators that should be taken into account for it to reach higher levels of sophistication.

**Indicators to Consider**

**Battery life**
A full charge should last at least a shift (8 - 10 hours). Most current devices last for less than half that time.

**Computational Power**
Substantial power required to create high-quality graphics and to reduce lag between a user’s movement and the display’s response.

**New Entrants**
Some analysts predict that big names such as Apple and Samsung will enter the AR market in the next one to two years.

**Price Point**
Most AR hardware is still expensive, with costs ranging from several hundred to several thousand dollars per user setup.

**Field of View**
The human field of view can extend to 180 degrees, the middle 114 to perceive depth and distance. Many devices today have fields of view just higher than 100 degrees.

Source: Deloitte University Press. For more companies, new ways of seeing.
Glasses AR applications are already available though in pilot stages, allowing hands-free working. Out of these applications, machine maintenance has the highest potential impact on the factory floor.

### Protecting Workers

AR lenses can protect workers from falling objects and enable them to spot hazards when repairing equipment.

**Benefits:**
- Danger anticipation and optimal escape route
- Quickly spot hazards and alert other people
- Real-time monitoring on factory status

### Machine Maintenance

Glasses AR can help with maintenance by overlaying instructions and providing contextual information directly over parts.

**Benefits:**
- Reduced risk of error
- Easier to follow
- Real-time instructions via video or voice calling
- Technicians can record procedures and receive remote feedback

### Accelerated Training

AR can simulate hazardous workplace conditions an employee may face. Instead of learning by paper, the user is immersed in the environment.

**Benefits:**
- Learning on the field
- Combination of technical data with real equipment
- Real-time monitoring and feedback

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**Source:** Buntz B. 10 Killer Applications of the IoT and Augmented Reality
Major companies such as BMW and Caterpillar are experimenting with AR maintenance

Augmented machine maintenance in different companies

**Elevator Maintenance**

Thyssenkrupp technicians can see maintenance instructions displayed on top of their view. As the smart glasses are equipped with a microphone and camera, technicians can share what they are seeing and get real-time feedback on their work.

They can see video tutorials and (virtual) service manuals while hands free. HoloLens accepts voice commands.

**Tractor Maintenance**

Caterpillar is employing AR to guide technicians through the process of repairing and maintaining their tractors and heavy-duty machines.

While seeing the real tractor, the instructions on how they should proceed are clearly displayed.

**Vehicle Maintenance**

When a mechanic looks at the engine of a BMW, a 3D colorful display is laid over the top of the original engine view.

The glasses are used to diagnose where the fault is and will take the wearer through step-by-step instructions to fix it.

A 3D animation will then play to demonstrate to the mechanic how to remove the relevant part.

Source: Jing, S. Augmented Reality: Applications in Manufacturing and Maintenance
There are two types of maintenance activities: preventive & corrective. We believe both are addressable through AR technology, although preventive maintenance can be easier to implement.

**Projected Benefits**

The expected benefits of employing smart glasses for maintenance are:

- Increased safety
- 15% productivity increase
- 25% error reduction
- 20% shortening the learning curve

**Typical smart glasses characteristics are:**

- Video calling
- Login & password
- GPS tracking
- Encrypted communications

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**Preventive Maintenance**

Routine maintenance activities, as they are well documented and standardized, are suitable for AR. The glasses can display the next steps in the procedure and get live feedback. Technicians can also consult digital manuals and videos.

**Corrective Maintenance**

Although corrective maintenance is unpredictable in nature, with the help of AI, the application will get smarter through time, and would be able to provide more detailed repair instructions for different machines. The more data it collects, the faster it could provide solutions to a diverse set of problems.

Source: Sintra Tech
The AR maintenance steps and diagnosis should be well documented and allow for standardization, as to provide a scalable, reliable solution.

- **Build a database of maintenance processes and components**
- **Create a set of maintenance tasks and steps**
- **Create user profiles with different privileges**
- **Ensure that operators, access the updated content**

- **While on work, technicians are supported with real-time info and feedback**
- **Data collected on site can be sent to the enterprise backend**
- **Information is accessible online to track execution status**
- **The same system can be used to support training**
Factory floor training, validating design features, logistics and field service are some of the use cases for this technology.

Motivation to implement AR

- **14.1 M**
  - The number of U.S. enterprise workers expected to utilize smart glasses by 2025

- **$1 B USD**
  - Projected yearly cost savings from smart glasses in the field-service industry starting in 2017

Steps involved in building an AR business case

1. **Providing the bottom line**
   - Compare the new AR process with existing one, how will it save resources and time?

2. **Telling a use-case story**
   - Give a story from the point of view of the service tech or factory worker, describing how their job will change for the better

3. **Show the tech in action**
   - Pilot stages serve this. Factory workers have to validate AR glasses usage (both monocular & binocular)

Source: ¹Forrester Research, ²Gartner
AR is now a reality in many companies around the world. Futuristic in nature, it is expected to be the next computing platform.

<table>
<thead>
<tr>
<th>Takeaways</th>
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<tbody>
<tr>
<td>AR offers a new way of processing information</td>
</tr>
<tr>
<td>Big firms like Apple, Samsung, Caterpillar and BMW are investing heavily on AR technology</td>
</tr>
<tr>
<td>The price of implementing AR technology is expected to decline in the following years, as AR becomes mainstream</td>
</tr>
<tr>
<td>Mobile AR is growing, but for business purposes smart glasses are promising due to the hands-off approach</td>
</tr>
<tr>
<td>Smart glasses technology has improved exponentially in recent years, glasses are no longer seen as a dream technology</td>
</tr>
<tr>
<td>Monocular smart glasses allow for less field of view obtrusion but do not provide a true AR experience as binocular smart glasses do</td>
</tr>
</tbody>
</table>