



# Augmented reality

## Specialised applications are the key to this fast-growing market for Germany

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As well as companies, private individuals are now increasingly making use of augmented reality. All too often, augmented reality is used as a synonym for smartglasses in the media. But it offers far more: supporting people in their day-to-day activities, extending their perception and facilitating communication.

The global market for augmented reality is expected to increase from its current EUR 500 million to EUR 7.5 billion by 2020. German companies, however, are at risk of falling ever further behind their international competitors, particularly those in North America and the Far East, where people are generally more open to such innovations.

In Germany, successful basic research into augmented reality has rarely led to commercial success to date. Despite its excellent reputation for research worldwide, Germany all too often fails to translate innovations into a viable business. Policy should continue to be aimed at strengthening basic research and creating an environment that favours innovative forms of finance (e.g. private equity) in order to provide greater stimulus for developing products and bringing them to market.

There is enormous potential for German companies offering specialised applications. Applications for the consumer mass market are mainly likely to be offered by companies from other countries. German companies would probably do well to offer customised services for commercial applications in niche markets where the tech giants have not become established.

Augmented reality can be deployed at every stage of the value chain. Its opportunities for increasing efficiency are particularly relevant for an ageing and shrinking population as they can help to mitigate the increasingly evident staffing problems caused by a shortage of skilled workers. Given that this is one of the greatest challenges of demographic change in Germany, companies here could clearly benefit. That is why it is important not to write off the technology in its entirety, simply because of individual applications, but instead to contain the risks by putting a legal framework in place so that the opportunities can be seized.

Business success does not happen by itself. Representatives from the technology sector, finance and politics must come up with concrete answers to the many different questions surrounding this issue as soon as possible. These questions relate to all kinds of areas, including the user-friendliness of control and image display, battery and computing power, confidentiality, standardisation and infrastructure.



## Augmented reality

### Maintenance made easy

1

Graphical display of information on the machine's condition and the necessary steps make maintenance easier



AR device indicates the temperature on the component and shows where to fit the replacement part on the machine

Source: DAQRI

### Augmented reality covers a broad spectrum

All too often, augmented reality is used as a synonym for Google Glass in the media. These smartglasses have created considerable controversy about invasion of privacy owing to their facial recognition functionality. Unfortunately, this means that discussions about the opportunities and risks of augmented reality often lead to portrayals of horrific dystopian scenarios in which everyone is under surveillance.

The fact is that augmented reality is far more than the much-discussed smartglasses.<sup>1</sup> Augmented reality primarily supports people in their day-to-day activities, extends their perception and facilitates communication. That is why it is important not to write off the technology in its entirety, simply because of one individual application among many, but instead to contain the risks so that the opportunities can be seized.

### A fascinating idea that has been around for some time

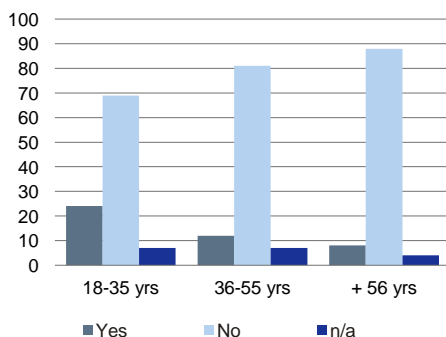
2

Augmented reality is sometimes seen as a brand new idea. In fact, scientists began conducting research in this field a long time ago, although they admittedly did not call it that. Take Ivan Sutherland, for example. A professor of electrical engineering at Harvard University, he built the first augmented reality head-mounted display back in 1966. Then in the early 1990s, engineers at Boeing developed augmented reality software for aircraft maintenance that was aimed at improving the quality of the work by pinpointing exactly the right spot on the aeroplane where the replacement part needed to be installed. Also in the 1990s, Louis Rosenberg created a screen for the US Air Force that was designed to make important information more visible to fighter pilots. The US Army developed completely new contact lenses that enable wearers to focus close up and far away at the same time. The initially exorbitant prices for the necessary hardware and software, as well as the enormous complexity of the equipment, meant that augmented reality remained the preserve of scientists, the military and large companies for a long time. The first person to break into the consumer mass market was Bruce Thomas in 2000 with his gaming product. Another crucial step for the consumer market was the Wikitude app for smartphones. Wikitude, which was released by the Australian company Mobilizy in 2008, combines live pictures from a smartphone camera with local information from the internet. The vision underpinning this business model is for augmented reality to become a permanent companion and general tool in our everyday life.

### Familiarity lower among older age groups

3

Q: "Do you know what augmented reality is?"; % of respondents



N=1576

Source: Stratcast

### The definition is strongly context-dependent

In computer science, augmented reality is mostly linked with virtual reality, positioning it in the 'reality-virtuality continuum' as mixed reality or enhanced reality.<sup>2</sup> By contrast with virtual reality, in which the user is fully immersed in a virtual world, augmented reality enhances the real world by providing additional information and technical assistance.

Augmented reality is sometimes mistakenly described as an enhanced viewing device. But augmented reality actually describes the much more broad-based development of applications designed to enhance the real world with virtual information and enable the user to interact with it in real time. Augmented reality provides intuitive, visual assistance to significantly reduce the complexity of tasks. As with other areas of innovation, the term 'augmented reality' is often vaguely defined and may have different areas of focus or different meanings depending on the context – sometimes perhaps quite intentionally. This vagueness often results in exaggerated expectations that are then bound to be disappointed, giving this idea – that is as useful as it is fascinating – a bad reputation among the general public.

<sup>1</sup> See Heng, Stefan and Ann-Kathrin Hörster (2014). Augmented reality: Fears should not completely overshadow the opportunities that beckon. Talking Point. Deutsche Bank Research. Frankfurt.

<sup>2</sup> See Paul Milgram et al. (1994). Augmented Reality; or Kyoto, Azuma, Ronald (1997). A Survey of Augmented Reality.

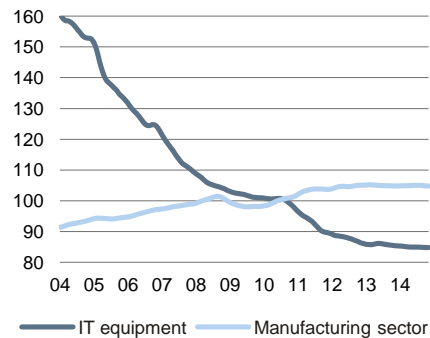


## Augmented reality

Producer prices for hardware have fallen by 47% since 2004, overall index up by 15%

4

Producer price index, 2010=100, DE



Source: German Federal Statistical Office

### Augmented reality should not be understood as just hardware

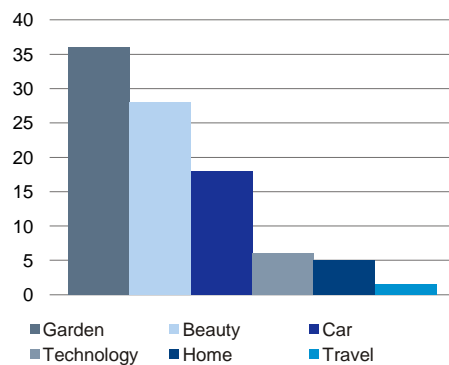
Contrary to perception, the end device for augmented reality is not a pair of smartglasses but the ubiquitous smartphone or tablet. In the medium term, smartglasses could acquire greater importance, at least temporarily, whether in the private or, more likely, the professional context. After all, smartglasses are both a receiver and a convenient monitor in one. They enable users to perceive visually presented, context-dependent information without having to look as far away from what is actually happening around them as they would if they had to look at the screen on their smartphone. Smartglasses are therefore revolutionising the expectations of end users as to how situational information should be displayed.

Nevertheless, smartglasses are certainly not the end device for all developments in the augmented reality segment. It is already clear that other wearables (clothing and accessories fitted with sensors and actuators<sup>3</sup>) will gain importance. One example is the smartwatch, which featured particularly prominently at CES (a global consumer electronics and consumer technology trade show) in Las Vegas. Of course this watch does much more than tell the time: it also offers additional applications covering everything from communications (telephone calls, text messages) and calendar management to the control of devices, lighting and climate technology in the smart home.

Wide range of possible applications for augmented reality

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Question: "What virtual application areas can you envisage?"; surveyed end users, DE, %



Source: mafo

### End devices are simply a platform for developing applications

To understand the opportunities and risks of augmented reality, it is essential to look beyond the end devices. Smartphones, smartglasses and wearables of course offer many useful features. But just as a smartphone without any apps has very little 'smart' functionality, other end devices can only provide the full benefit of augmented reality if they include the necessary software. Particularly in specialised application areas, tailor-made software and end devices are required that will not be available 'off the peg'. The number of developers working on augmented reality is expected to grow in parallel with the expansion of the mass market, especially in the area of open innovation.<sup>4</sup> The programming work could be used in smartphones, smartglasses and wearables as a stepping stone for far-reaching innovations.

### Successfully deployed in many different areas

We must not let our understanding of augmented reality be shaped by futuristic or, in some cases, frivolous products. After all, companies and private individuals are already using this innovative technology in all kinds of areas, even if they do not always explicitly use the term 'augmented reality'. The areas of use range from consumer electronics, multimedia, games, lifestyle, healthcare and education to process optimisation, particularly in the huge growth area known as Industry 4.0.<sup>5</sup> The examples below illustrate the opportunities and risks of augmented reality. We will start by setting out some of the ways in which augmented reality can be used in sectors with high risks and high costs. These will be followed by examples from other promising areas of application, such as gaming, navigation and industrial automation.

<sup>3</sup> An actuator converts electromagnetic signals into mechanical movement, pressure or temperature and can thus form an active part of a control system.

<sup>4</sup> See Chesbrough, Henry (2014). *New Frontiers in Open Innovation*. Oxford.

<sup>5</sup> See Heng, Stefan (2014). *Industry 4.0: Huge potential for value creation waiting to be tapped*. Talking Point. Deutsche Bank Research. Frankfurt.



## Augmented reality

Varied range of application areas

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Highly specialised applications	Mass applications
<b>Military:</b> <ul style="list-style-type: none"> <li>- Improved training for fighter pilots</li> <li>- Faster transfer of information in crisis situations</li> </ul>	
<b>Medicine:</b> <ul style="list-style-type: none"> <li>- Improved flow of information in the delivery room</li> <li>- Simplified training thanks to visualisation</li> </ul>	<b>Medicine/wellness:</b> <ul style="list-style-type: none"> <li>- Real-time health data available for everyday use</li> </ul>
	<b>Gaming:</b> <ul style="list-style-type: none"> <li>- More engaging game action on consoles and smartphones</li> <li>- More life-like, interactive gaming with wearables</li> </ul>
	<b>Navigation and tourism:</b> <ul style="list-style-type: none"> <li>- Warning of dangers on the roads</li> <li>- Context-dependent, real-time information about tourist destinations</li> <li>- Visualisation of sights that no longer exist</li> <li>- Trips to the swimming pool, zoo or theme park made more exciting by new entertainment options</li> </ul>
<b>Architecture:</b> <ul style="list-style-type: none"> <li>- Visualisation of major construction projects</li> </ul>	<b>Architecture:</b> <ul style="list-style-type: none"> <li>- Simplified interior design thanks to 3D depiction of blueprints</li> </ul>
<b>Production/marketing/service:</b> <ul style="list-style-type: none"> <li>- Visual support for product development</li> <li>- Facilitation of international teamwork</li> <li>- New marketing opportunities in sales</li> <li>- Easier maintenance of complex products</li> </ul>	<b>Production/marketing/service:</b> <ul style="list-style-type: none"> <li>- A more exciting shopping experience</li> <li>- Help with servicing of household appliances</li> </ul>

Source: Deutsche Bank Research

### High-risk, cost-intensive industries are driving development

Sectors with exceptionally high-risk, cost-intensive activities have been among the main players in augmented reality for decades. The stand-out examples here are the military and the healthcare sector as they can particularly benefit from augmented reality.

### A survival aid for fighter pilots ...

AR already widespread in the military, ... 7



Source: BAE Systems

As with many other revolutionary inventions, augmented reality was primarily developed for military purposes. The technology is used to train air force officers and help them to maintain their skills. It enables pilots and weapon system operators in fighter jets to familiarise themselves with new instruments and complex tasks in a safe setting. The US armed forces use augmented reality as part of a network-centric warfare strategy for modern crisis intervention. For these military applications, in which even the tiniest of errors can lead to human and financial catastrophe, augmented reality undoubtedly represents a technological quantum leap.



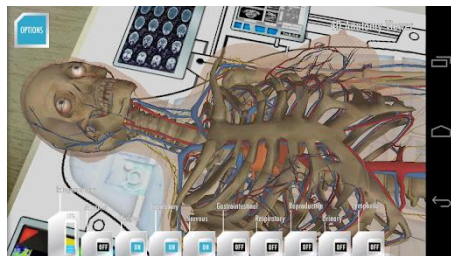
... and a lifesaver in situations of extreme stress

But augmented reality is also deployed successfully in civilian life. It is particularly useful for tasks that require people to digest complex information while under significant time pressure and faced with high risks. There are plenty of pertinent examples. Soldiers on combat missions, medical professionals and those working in civil emergency management all come under a huge amount of strain. Surgeons can use smartglasses to display computed tomography scans of their patients so that they can operate more precisely and therefore less invasively. This shows that augmented reality technologies are especially helpful in situations that test peoples' resilience to the limit.

In healthcare, would-be medics receive better training ...

... in medical training, ...

8



Source: DAQRI

Augmented reality also comes into its own in the training of doctors and highly specialised nurses. Many publishers are working on cross-media textbooks enhanced with augmented reality functions. These help to visualise the human anatomy and build on the intuitive teaching of complex processes.

... and patients have greater control

Augmented reality is also used by patients themselves so that they can maintain as much control as possible over their everyday life. There are state-of-the-art contact lenses, for example, that directly warn diabetics of dangerous changes in their insulin levels. The services made possible by augmented reality primarily benefit patients' health, but ultimately they can also relieve the strain on the healthcare system as a whole.

Augmented reality turns gaming into a highly engaging experience ...

Gamers are increasingly being won over by what has long been commonplace for military and civilian specialists on real-life missions. Augmented reality makes the game action even more engaging and closer to reality. Game consoles such as Nintendo Wii and Microsoft Kinect follow this approach, as do 'social games' such as Google's collaborative hacking game Ingress. These products mean users can play tennis in their sitting room in the morning and then solve virtual crimes on their smartphones while out and about in the evening. If they enable users to engage senses other than their sight, for example by means of wearables, gaming would become multisensory and thereby considerably more interactive and lifelike.

... and can enhance a trip to the swimming pool, as well

Augmented reality might even come into its own if holidays abroad are too expensive or too time-consuming. The Fraunhofer Institute for Applied Information Technology (FIT) is working with the Korea Institute for Advancement of Technology on underwater augmented reality technology as part of the AREEF project, bringing a virtual coral reef to your local swimming pool. Although augmented reality snorkelling may not offer the full Great Barrier Reef experience, the technology opens up a multitude of interesting possibilities for water parks, zoos and theme parks.





## Augmented reality

### The augmented reality-travel guide: a constant companion

... for navigation, ...

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Source: Ullmann, Deutsche Bank

It is also clear that augmented reality will help us to make significant progress as far as travel is concerned. In future, this innovative technology will not only guide people to their destination in the same way that the well-established sat-nav does, it will also provide people with real-time, context-dependent route information that is specifically important to them. Above all, it can highlight real dangers by displaying virtual objects in a way that enables them to be perceived quickly and intuitively. Jaguar Land Rover, for example, is working on a 'virtual windscreen' that projects the current braking distance directly onto the windscreen and points out suitable overtaking opportunities. The Skullly motorcycle helmet takes a similar approach. This premium product for a selected niche market enables motorcyclists to keep an eye on significant occurrences in the traffic behind them without having to keep looking in the rear-view mirror.

Although the emphasis is on the avoidance of danger in the examples above, this is by no means the limit on the information that augmented reality can provide. The technology can also be focused on providing context-dependent tourist information along a route in real time, for example visually promoting special offers for tourist attractions, retail outlets, restaurants and hotels.

... for the simulation of construction projects, ...

10



Source: Fraunhofer FIT

Augmented reality also enables visitors to experience sights that no longer or do not yet exist. There is a smartphone app that shows how Christchurch in New Zealand used to look before the devastating earthquake in 2013. Long-gone buildings from antiquity can be vividly recreated and realistic images of planned construction projects can be displayed – an option that architects, town planners and interior designers are increasingly deploying.

During the planning stage for the reconstruction of an old quarter or the building of a skyscraper, for example, it is possible to visualise exactly how the space will look, how the shadows will fall and how the construction will affect local wind conditions. As part of the INSITU project, the Fraunhofer FIT is currently developing a method of visualisation like this that will help not only the specialist but, more importantly, also the layman who is not versed in spatial thinking. This may contribute to a more rational debate about large-scale projects, which often can descend into emotional arguments in society.

In the medium term, these new possibilities should turn augmented-reality-enabled end devices, whether smartphones or special visual displays, into indispensable digital travel guides. The direction that this technology is likely to take can already be seen from the HERE City Lens smartphone app, which was recently bought by a consortium of Audi, BMW and Daimler. The app combines traditional GPS navigation with a camera view that displays shops, hotels and restaurants in the line of sight and, if requested, overlays them with additional information, particularly reviews.

Augmented-reality-enabled end devices become an indispensable travel guide

### A useful aid at every stage of the value chain

Industry offers a broad range of applications for augmented reality all along the value chain, from product development and production through to marketing and servicing. These are examined in more depth in the following examples.

#### Relevant support for product development ...

Virtual methods such as simulation-supported modelling have long played a key role in product development. Augmented reality is a genuinely useful technology here because a three-dimensional visualisation is of course much more realistic



## Augmented reality

Augmented reality is key to simulation-based product development

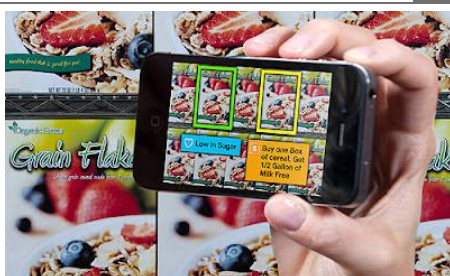
than an image on a two-dimensional screen. In future, therefore, physical models and prototypes are likely to be used less and less. This makes it easier and cheaper to design products, particularly those that will be launched with many variants. Consequently, the main driving forces behind these 'spatial augmented reality' systems are automotive developers.

... through production ...

A globalised value chain calls for technologies that help teams scattered all over the world to work together. Given what is now technologically possible, telephony and video conferencing appear rather inadequate. Augmented reality, however, enables people to interact and see each other in real time. For example, engineers at a firm in Germany can use a system such as Microsoft HoloLens to visualise a 3D model of a factory to be built in China. This greatly reduces the need for travel and enables them to refer to a 3D model that everyone can see when discussing the next steps with the local construction manager so that they can explain exactly what they mean. This method of working could reduce costs without significantly detracting from the collaborative effect. The technology will therefore be particularly beneficial to the development of Industry 4.0: in the highly integrated, data-driven 'smart factory' of the future, the rapid, reliable and seamless transfer of information along the value chain, from the supplier through to the end customer, will be essential. Augmented reality thus provides an additional way of improving the overall flow of information.

... and marketing ...

... as an assistant in the supermarket, ... 11



Source: IBM

Further along the value chain, marketing of the completed product offers some very interesting opportunities for using augmented reality. There are already smartphone apps that show how furniture on display in a shop will look in the customer's own home. Furthermore, IBM's shopping assistant helps customers to find products in the supermarket that match their criteria, pointing out all of the special offers on a shelf or all of the organic products as customers make their way around the store. Such technological aids make shopping more fun and more of an experience, thereby helping retailers to stand out from their competitors.

As with product development, the technology has the added benefit of enabling retailers to show customers the possible variants without having to physically keep them all in stock. This makes it simpler to sell personalised products and considerably reduces warehousing costs.

... and for servicing of large machinery 12



Source: DAQRI

... through to servicing

The use of augmented reality by no means ends with the sale of a product and it can pave the way for a long-lasting and strong customer relationship. Servicing and after-sales are playing an increasingly important role in this regard. One example is Mitsubishi Electric's meView, which supports the servicing of air conditioning systems. Its software automatically identifies the model in question and displays the necessary maintenance activities on the actual object. Car manufacturers are deploying similar strategies to simplify repairs of vehicles that are available in many different variants.

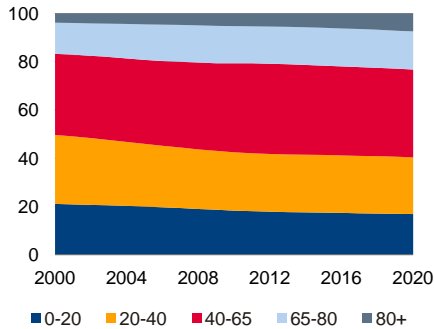


## Augmented reality

### Ever fewer people of working age

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Age structure of the total population, DE, %

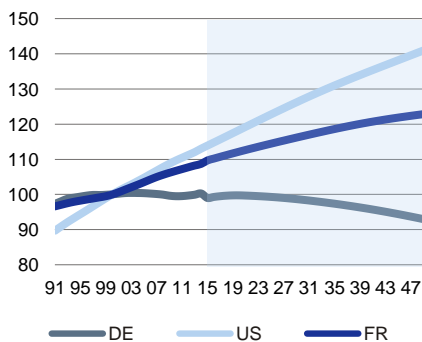


Sources: German Federal Statistical Office, Deutsche Bank

### Germany faces a significant demographic challenge

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Population size, index, 2000=100

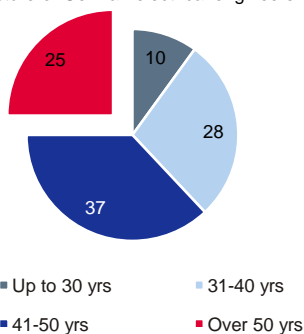


Sources: OECD, Deutsche Bank

### Ahead of the retirement wave

16

Age structure of German electrical engineers



Percentage, 2012

Source: ZVEI

## Focusing on specialised applications should help Germany

Overall, therefore, augmented reality can be deployed at every stage of the value chain and opens up huge potential for efficiency improvements, particularly in production and servicing. These opportunities for increasing efficiency are particularly relevant for an ageing and shrinking population as they can help to mitigate the increasingly evident staffing problems caused by a shortage of skilled workers. Given that this is one of the greatest challenges of demographic change in Germany, where the population is set to decrease, companies here could clearly benefit from using augmented reality.

## A fast-growing market

Selected companies in the augmented reality market

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Google	Smartglasses
Innovega	Smartglasses
Microsoft	Smartglasses
Olympus	Smartglasses
Vuzix	Smartglasses
HP	Hardware
Applied Research Associates Inc.	Hardware for military applications
BAE Systems	Hardware for military applications
Id Software	Gaming software
SCE London Studio (Sony)	Gaming software
Skully	Hardware
Metaio	Hardware and development kits
Nokia	Software
Daqri	Software
Layar QR-Code	Software
Mitsubishi	Software
Fraunhofer FIT	Construction planning software
SAP	Data processing software
IBM Shopping Assistant	Software
Id Software	Software for gaming
SCE London Studio	Software for gaming
Bayer	Software for laboratory work
KÖTTER Services Mobiles	Software for security
digitalSTROM	Software for control
Kautex Textron	Software for maintenance

Source: Deutsche Bank Research

The augmented reality market offers substantial potential for expansion. Technology consultancy Juniper Research<sup>6</sup> reckons that the number of users will rise from 60 million to around 350 million within five years, which equates to an average growth rate of 35% per year. At the same time, the global market is expected to increase from its current EUR 500 million to EUR 7.5 billion by 2020, which would mean average growth of some 72% per year.

This growth forecast is far from certain. Among other factors, it is based on the assumption that augmented reality will conquer the mass consumer market very quickly. This will only be possible, however, if prices for the IT hardware and state-of-the-art data transfer (particularly via mobile technology) continue to fall sharply in parallel with a rapid improvement in capability.

<sup>6</sup> Juniper Research (2014). Mobile Augmented Reality. Basingstoke.





From a geographical perspective, Juniper Research predicts particularly fast growth in the North American and Latin American markets. The North American market is anticipated to grow from just under EUR 160 million to around EUR 3 billion within the next five years (average growth: 80% per year). Given this considerable potential for growth, it is no wonder that various companies with different core businesses are already battling it out in the augmented reality market.

Hurdles to broader adoption

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Technical	User-friendly operation/control
	Visualisation in the line of sight
	Lasting battery performance
	Sufficient computing power
Political/regulatory	Reliable data protection
	Dependable, high-performance network infrastructure
Economic	Short lead times between research and product readiness

Source: Deutsche Bank Research

### A few hurdles still to surmount

Augmented reality therefore has a great deal of commercial potential in many different application areas. But if this potential is to be harnessed, solutions urgently need to be found to overcome the challenges, whether they relate to user-friendliness, battery and computing power, data protection or the availability of data networks. Let us now look at those challenges in more detail.

#### Showstopper: user-friendliness of control and image display

The advantages and convenience must be plain to see

The need for user-friendliness is particularly important as far as control and image display are concerned. Smartphones, tablets and even smartwatches are leading the way when it comes to displaying images. But there is still room to improve on the level of user-friendliness that they offer, for example by means of devices that show the image directly within the user's natural field of vision. This eliminates the need to move the head in order to see the information. Operation within the user's field of vision is undoubtedly less distracting than with the normal end devices currently in use. This means that the huge potential in this area lies not only in augmented reality smartglasses but also in augmented reality contact lenses.

The success of augmented reality also hinges on how the interaction between man and machine is controlled. Particularly promising types of control appear to be those that rely on people's intuitive, natural body movements (especially gesture control) in order to interpret commands.

#### Battery and computing power in need of improvement

Better batteries required

Significant progress still needs to be made with regard to the battery and computing power of end devices before the technology is fit for everyday use by the general public. Although one of the features of augmented reality is real-time interaction, the necessary data is not always computed or made available quickly enough.



The battery performance of end devices also requires significant improvement. The batteries currently available often cannot power the mobile augmented reality systems for long enough and may even overheat during operation. In practice, these shortfalls massively reduce some of the particularly attractive theoretical opportunities of augmented reality.

Development hampered by data protection concerns

The developments represented by augmented reality glasses have come under heavy criticism from many quarters, particularly in Europe. Data protection advocates fear that augmented reality technologies will impinge on people's personality rights. The idea of smartglasses fitted with a camera and automatic facial recognition is seen as a particularly pernicious way of creating an omnipresent, integrated surveillance system and has generated a lot of public resistance. This has raised alarm bells at political level. The European Commission, for example, has identified significant data protection concerns about augmented reality in general as a result of the discussion about smartglasses. What is required is a binding legal framework for the use of personal data that covers as many countries worldwide as feasible. In Europe at least, major steps should be taken in this direction as soon as possible.

However, a survey conducted by management consultancies Frost & Sullivan and Stratecast found that the consumers who initially express concerns in theoretical discussions about an abstract technology soon set these concerns aside when they see particularly helpful practical applications.<sup>7</sup>

Data protection and data security are essential

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The fundamental concept of data protection is that everyone can decide for themselves which of their personal data is to be made accessible to whom and when. Data protection can be split into different aspects: protection against misuse of data, protection of information privacy, protection of the right of an individual to privacy and protection of privacy. The terms 'privacy', 'confidentiality' and 'data protection' are all used, depending on the specific context. It is not only individuals and companies but also government agencies that are interested in people's personal information. Because it is becoming much easier to capture, analyse and pass on data, this issue is growing in relevance with the advance of digitisation.

The different aspects of data security are integrity, availability and authenticity. Integrity means that data cannot be secretly amended. Availability refers to the ability to restore a system as quickly as possible and without significant loss or damage after a system failure has occurred. And authenticity relates to data being genuine, verifiable and trustworthy. The terms 'safety' (functional safety) and 'security' (information security) are both used, depending on the context.

Legislation in the EU places far greater weight on data protection and data security than laws in the United States do. The US Patriot Act, for example, requires US authorities to be able to access data that is stored or processed by a company that has a base in the United States, regardless of where this data is physically located. For European companies, in particular, the stipulations of the US Patriot Act undermine the Safe Harbor agreements on the handling of company data that had been reached at the start of this millennium.

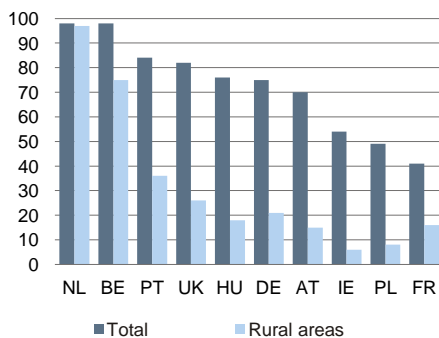
Essentially, the EU needs to very quickly bring in a single data protection regulation that can overcome the increasingly substantial challenges faced across the economy.

So far, the politicians appear unable to keep up with the emerging challenges in this area.

Mediocre rural coverage in Germany

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Internet users with data speeds of at least 30 Mbit/s, %



Source: European Commission

<sup>7</sup> See Münchner Kreis (2015). Digitalisierung. Achillesferse der deutschen Wirtschaft? Munich.



## Augmented reality

### Network bottlenecks a certainty

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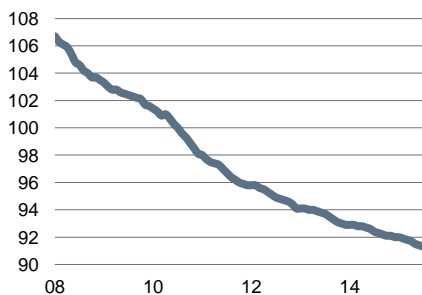
In view of the constant increase in IP volume, capacity shortages in the data network are no longer a remote possibility but an actual reality. Utilisation of network capacity varies significantly, depending on the time of day, the day of the week and the user group. Deutsche Telekom AG reports that 65% of its data traffic is generated by just 10% of its customers. Peak load is usually between 6pm and 10pm, although this can be strongly influenced by unusual events on any particular day.

Aware of the social and economic importance of high-performance data networks, political institutions worldwide have defined noble availability objectives. The European Commission wants all households in the EU to achieve a data speed of at least 30 Mbit/s by no later than 2020, with at least 50% of them achieving a minimum speed of 100 Mbit/s. Germany's own targets are even more ambitious than those of the European Commission. By the end of this year, at least 75% of German households should have an internet speed of no less than 50 Mbit/s. And by 2018, this should be the case for all 40 million households in Germany.

### Sharp fall in telecommunications prices

21

Telecommunications services, price index, 2010=100, DE



Source: German Federal Statistical Office

### High-performance communications networks required

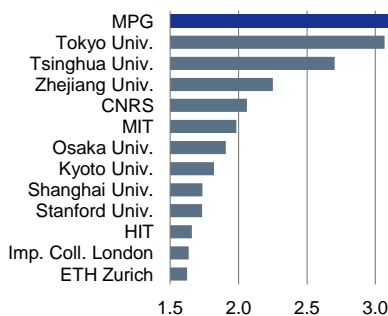
If a communications network does not deliver sufficient performance (particularly in terms of system availability and speed), there will be disruptions in the huge flows of data required for augmented reality, which could lead to serious problems in the value creation process. The prospects for the success of the new technologies therefore depend directly on the reach and performance of the communications network. The commercial feasibility of the many different augmented reality products is therefore closely linked to the rollout of modern data networks.<sup>8</sup> Potential new application areas are therefore an opportunity but also a challenge for telecommunications companies operating in both the mobile and fixed telephony sectors.

### German research at the forefront

#### Max Planck Society's research is especially prolific

22

Number of scientific publications on 3D in the field of augmented reality, '000



Source: Fraunhofer IGD

Despite all these challenges, Germany is undoubtedly well placed to tap into the impressive potential for development offered by augmented reality. Research into the wider augmented reality field is among the best worldwide. In a ranking of research publications, Germany tied for third place with Japan, with each accounting for 7% of all publications. The United States came first (21%), followed by China (14%).<sup>9</sup> The Max Planck Society (MPG) is especially prolific and leads the way worldwide in terms of the number of publications on three-dimensional effects in the field of augmented reality. With regard to patent applications, however, Japan recently overtook Germany to take second place behind the United States.<sup>10</sup>

Germany's leading position in research stands in stark contrast to the lack of real market success for German companies. Research organisations, companies and politicians in this country therefore need to step up their engagement. There needs to be a further strengthening of research, but also significant improvements in the conditions that favour innovative forms of finance (e.g. private equity). The huge potential opened up by research in Germany would then pay off financially for the country.

<sup>8</sup> See Heng, Stefan (2014). National IT Summit: Ensure progress away from the limelight as well! Talking Point. Deutsche Bank Research. Frankfurt.

<sup>9</sup> See Michael Astor et al. (2013): Marktperspektiven von 3D in industriellen Anwendungen. Berlin.

<sup>10</sup> There are significant differences in patent activity internationally. This means that the number of patent applications only has limited usefulness as an indicator of a country's propensity for innovation.

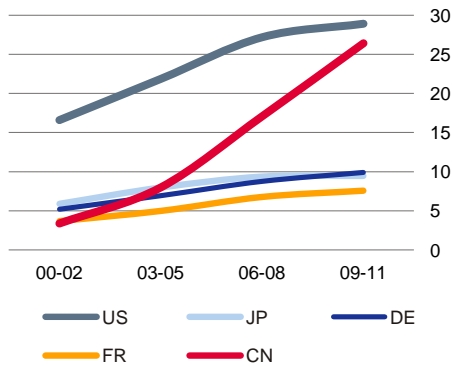


Augmented reality

Germany's potential lies in specialised applications

China catapults itself into second place 23

Number of scientific publications on 3D in the field of augmented reality, '000



Source: Fraunhofer IGD

Building on the leading position in Industry 4.0

Numerous augmented reality programmes launched by politicians

With Google and Microsoft leading the way, it is mainly the giants of the US software industry that are ideally positioned to bring smartglasses and the related augmented reality software to market readiness. Because their products are used both by private individuals and by companies, they have huge quantities of data and computing capacity at their disposal that will enable them to feed context-dependent information into the glasses in real time. Empirical evidence is making it ever clearer that data is becoming the key commodity that will provide the foundations for the profitable business models of the future. Google operates 13 data centres worldwide and handles more than 100 billion searches per month, making it ideally positioned for the future.<sup>11</sup>

The bundling of smartglasses with existing services for consumers, such as search engines, email, video chat and social networks, also creates important synergies that could make products from Google, Facebook and Microsoft appear particularly attractive to consumers. This critical data aspect clearly puts German companies at a disadvantage. That is why their opportunities in this business lie more in specialised niche services for commercial applications. The development of tailor-made products and services requires a great deal of specialist knowledge and close collaboration between the manufacturer and the user. American IT companies have not offered this so far. In this regard, smaller German firms that focus on one of these application areas are therefore better positioned than the tech giants. German companies occupy a leading position in automation technology and also in Industry 4.0. If these companies make useful additions to their product portfolios in the area of augmented reality and thus create further synergies, they should be able to build on their leading position in Industry 4.0.

Support from politicians and society required

Germany and the EU have numerous political programmes aimed at driving augmented reality forward. These include the Federal Ministry of Education and Research's programme for reliable wireless communication in industry, the Federal Ministry for Economic Affairs and Energy's HIGHtechLIGHTS programme and the European Commission's ICT 2015 programme, all of which also provide financial support for augmented reality projects for industrial or medical equipment applications.

Besides financial assistance, however, there are other pressing questions that have to be addressed and some initial steps have already been taken in Germany, including the Digital Agenda, the Intelligent Connections strategy and the Network Alliance for a Digital Germany.<sup>12</sup> This shows that the improvement of data protection at international level and support for full broadband coverage are now high up on the political agenda. However, these pronouncements need to be quickly followed up by action. Otherwise, German companies are at risk of falling ever further behind their international competitors, particularly those in North America and the Far East, where people are generally more positively inclined towards such innovations. It is therefore all the more important that German companies' products and services are focused on increasing efficiency in commercial settings in order to cope with future challenges and less on entertainment applications for consumers.

<sup>11</sup> Page, Larry (2013). 2013 Founders' Letter.

<sup>12</sup> See Dapp, Thomas-Frank (2014). Big Data – The untamed force. Current Issues. Deutsche Bank Research. Frankfurt.





One early morning in the future, a project team member gets in his self-driving car and uses the journey time to work on a virtual prototype with his international colleagues. The specialists on this diverse team are not only located all over the world, they represent various cultures and some have physical disabilities. Smartglasses and wearables level the playing field and overcome differences that initially seem to separate the team members, resulting in highly productive teamwork. An intelligent glove, for example, translates a deaf colleague's sign language into text. In the afternoon, our project team member wants to buy a new computer. Again, he uses virtual technology to select the components himself. This one-off product is built immediately in the smart factory. In the evening, he puts on his smartglasses to attend a long-distance learning course at a virtual university. As a treat at the end of a successful day, he takes on the role of goalkeeper in FIFA 2028, using special augmented reality football boots and gloves. These give him the impression that his parquet floor is actually a football pitch and the virtual ball is made of genuine leather. At half time, his contact lenses tell him how many calories he has burned so far and give him any early warnings about strain or injury

### Outlook: commercial augmented reality applications provide a particular opportunity for German industry

As with other areas of innovation, the term 'augmented reality' is often vague and may have different areas of focus or different meanings depending on the context – sometimes perhaps quite intentionally. This vagueness often results in exaggerated expectations that are then bound to be disappointed, giving this idea a bad reputation among the general public.

#### An everyday assistant

The scenario described in the text box above is still a long way off, and some details may even seem disturbing. Nevertheless, it shows how augmented reality could provide assistance in many aspects of our everyday life in future. Augmented reality therefore offers considerable potential. This is clearly demonstrated by the fact that the technology is already being used by companies and private individuals in all kinds of areas. The market for these innovative products is expected to expand rapidly. Whereas current spending on augmented reality products amounts to only around EUR 500 million per year, this figure could rise to EUR 7.5 billion by 2020, which equates to an average growth rate of some 72% per year.

#### A technology with many applications, ...

#### ... from medicine to design

Smartglasses, which are mainly being developed by American software and internet giants, will account for a significant portion of this market. They have the quantities of data and the synergies that are needed to make augmented reality attractive to the end user and can thus make the technology fit for the mass market. But the technology has many other possible applications, from medicine and wellness to air conditioning repairs and car design. Empirical evidence is making it ever clearer that data is becoming the key commodity that will provide the foundations for the profitable business models of the future.

However, German companies also have good prospects for tapping into this growth, particularly in the area of specialised commercial applications. These types of application require tailor-made software solutions and close collaboration between the manufacturer and the user, something that American IT companies have not offered so far.

To harness this potential, representatives from the technology sector, finance and politics must urgently come up with answers to the many different questions directly linked to this issue, whether they relate to the user-friendliness of control and image display, battery and computing power, confidentiality, standardisation or infrastructure. The first steps aimed at answering these questions in Germany include the Digital Agenda, the Intelligent Connections strategy and the Network Alliance for a Digital Germany. This shows that the improvement of data protection at international level and support for full broadband coverage are now high up on the political agenda. However, these pronouncements need to be quickly followed up by action.



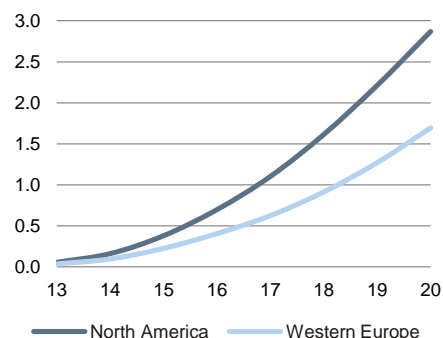
## Augmented reality

### A particular challenge for Germany

Western Europe at risk of falling further behind

25

Augmented reality market, EUR billion



Sources: Juniper Research, Deutsche Bank Research

Otherwise, German companies are at risk of falling ever further behind their international competitors, particularly those in North America and the Far East, where people are generally more open to innovations.

In addition, the opportunities for increasing efficiency are particularly relevant for an ageing and shrinking population as they can help to mitigate the increasingly evident staffing problems caused by the resulting shortage of skilled workers. Given that this is one of the greatest challenges of demographic change in Germany, companies here could clearly benefit from using augmented reality. That is why it is important not to write off the technology in its entirety, simply because of individual applications, but instead to limit the risks so that the opportunities can be seized.

Government programmes fund both basic research and profit-driven research, making them a necessary support for industry. Germany is already one of the leading players in basic research. But when it comes to translating research findings into market-ready products, German companies are less successful than their international rivals. Research organisations, companies and politicians in this country therefore need to step up their engagement. There needs to be a further strengthening of research, but also significant improvements in the conditions that favour innovative forms of finance (e.g. private equity). The huge potential opened up by research in Germany would then pay off financially for the country's economy. Moreover, such an approach would enable politicians to encourage the development of products that comply with the German understanding of data protection. Ultimately, data protection cannot be enforced solely by means of restrictive laws. It also requires the use of innovative technology, such as processes that automatically encrypt and anonymise data.

### Laws by themselves are not enough

Society also needs a culture that fosters a fair discussion about the opportunities and risks of technologies. Above all, it is important not to reduce the debate about augmented reality to just one end device, such as Google Glass, and the associated criticism. Ultimately, the fears being highlighted in the current discussions should not cause us to lose sight of the economic and social opportunities of augmented reality here in Germany.

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