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Feasibility Study on Augmented Supplier Audit

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Purpose: *Conventional supplier audits are outdated as traditional instruments in supplier management. At least since travel and contact restrictions were imposed due to Covid-19, digital instruments must be used for remote supplier audits. Augmented Reality (AR) technology supports international supply management to work more efficiently and sustainably.*

Methodology: *For this purpose, the feasibility of Augmented Supplier Audit in Industry applications will be analyzed based on a literature review and use case research. The focus is on hardware/software, legal/normative specifications as well as procedural feasibility. First research findings are pictured in a use case and described in this paper.*

Findings: *The study shows the high potential of Augmented Supplier Audit as a standardized instrument in industry. Nevertheless, there are barriers to consider. Beside the lack of appropriate software applications to execute a fully integrated Augmented Supplier Audit, data security and the provision of hardware at supplier side has to be defined.*

Originality: *Current research activities on technology-supported supplier audit are primarily limited on video conferences, the prevalence of remote audits in practice is marginal. However, since the beginning of the corona pandemic, (re)-certification audits are either postponed or allowed to be held remotely, whereby first practical experience could be generated.*

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1 Introduction

Due to the reduction in depth of value creation in many companies, the pressure on quality management in the supply chain is constantly increasing. The growing connection between suppliers and customers, as well as the push for new technological innovations, lead to increasing competitive pressure. As a result, companies are forced to abandon traditional supplier strategies and pursue new strategies to maintain competition. In this context, a target-oriented supplier management plays a key role, creating a link between the company and its suppliers. Companies must select those suppliers that meet their needs best and establish and maintain an optimal relationship with those suppliers. The benefits from working with an optimized supplier base are widely recognized in both practice and academia. (Obmann, 2014)

The term supplier management is only very generally defined in the literature and there is a high degree of disparity in terms of content. Thus, although the topic is discussed intensively, the extension of the understanding of the term is interpreted in different ways. In general, supplier management can be seen as a management process that encompasses the entire supplier-customer relationship from the beginning to the end of the cooperation, whereby the entire process can be divided into different phases, depending on the literature as shown in Figure 1.

A key factor of the model presented is the ability to integrate supplier management as a holistic process and to enable a systematic approach. This is achieved through segmentation into the individual phases of supplier management. The procedure for implementation is divided into these individual elements, whereby each individual phase includes risk assessment under the aspect of the respective design field as well as a possible phase-out process. This integrated risk assessment for each individual phase of supplier management distinguishes the planned model significantly from other models. Supplier development and -auditing represents an important step in the presented model and builds systematically on the results of the two preceding phases. This phase basically ensures suppliers potential in the future. Important task of this phase is to eliminate defined deficits through targeted measures to improve supplier performance. In addition, however, emerging risks must also be identified in an early

stage. For this reason, a supplier audit is an essential element in this context. This paper presented here deals with the important phase of the supplier auditing.

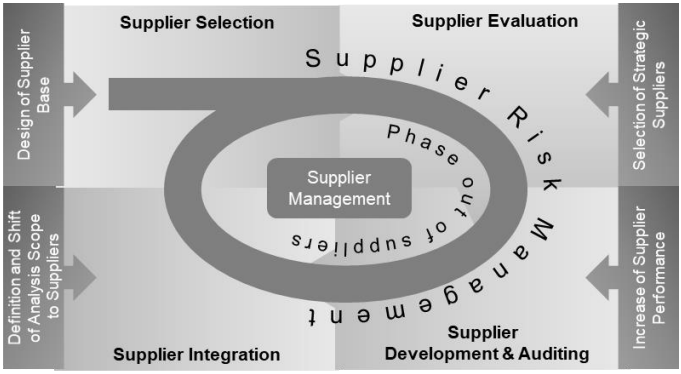

Figure 1: Holistic Supplier Management (Obmann, 2014)

An essential task of supplier management is, as already mentioned, to ensure that the company's needs are met at the right price and in the specified quantity at a given time, taking quality into account. To identify those suppliers who can also fulfill these criteria in the long term, careful supplier selection is an essential criterion, as the company's success depends on it. The goal of supplier selection is therefore to find the ideal supplier who can provide the desired service even in a long-term cooperation (Helmold and Terry, 2016).

Selecting the ideal suppliers is difficult because global networking means that suppliers can be located anywhere in the world, resulting in supply chains that span the globe with the result of a global supplier base which causes cost-intensive audits. The aim of the audits is to gain an insight into supplier's production sites to generate more information. This should include information about the suitability for a long-term cooperation and furthermore to what extent the supplier is able to provide the desired service. (Hofbauer, Mashhour and Fischer, 2009)

As already mentioned, supplier audits that are carried out in widely dispersed locations often lead to high costs. Furthermore, valuable human resources are not available for the

organization due to long travel distances. To maintain competitiveness in the future, it is necessary to reduce the aforementioned disadvantages in order to save costs, among other things. Nevertheless, it should be possible to determine and continuously monitor the ideal supplier by means of more efficient supplier audits. (Peddie, 2017)

2 Supplier Audit as Part of Supplier Management

As already mentioned at the outset, supplier audits primarily pursue the goal of increasing the performance level of suppliers, for example by imparting know-how or training employees.

Audits are generally divided into internal and external audits. In addition, external audits are further divided into second-party and third-party audits. The two types of audits – supplier and certification audits – are part of these external audits (Kallmeyer and Kretschmar 2019).

Figure 2 illustrates the relationships between these different types of audits.

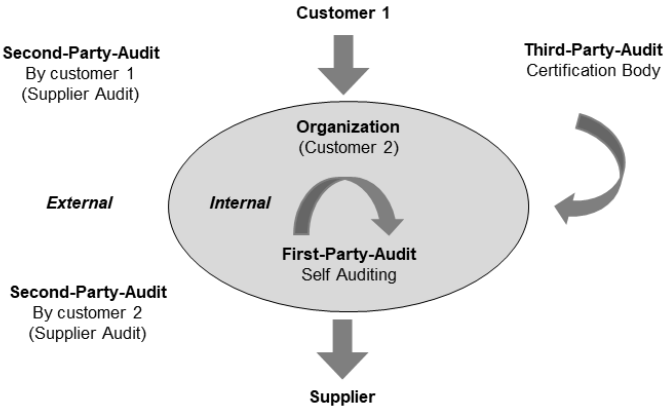

Figure 2: Internal and External Audits (Gietl and Lobinger, 2012)

Internal audits are usually performed by or on behalf of an organization and are basically for internal purposes. Therefore, this type of audit is often attributed to first-party audits. Employees of the organization usually perform the auditing of these internal audits. However, it is also possible to use consultants as deputies for an internal audit if, for example, the company does not wish to train its own employees for this activity. Internal audits are carried out to check the management system for conformity to standards.

The focus is primarily on identifying potential for improvement and thus also represents a component of the continuous improvement process (CIP) (Kallmeyer and Kretschmar 2019) (Gietl and Lobinger, 2012).

External audits, on the other hand, are carried out on behalf of the company's own organization or that of a customer. The auditing by an external party and thus by a person outside the organization is usually carried out by an auditor of a certification body. For the execution of these audits, rules exist according to which generally applicable checklists and questionnaires have been drafted, which are based on these sets of rules. External audits can be divided into second- and third-party audits. The supplier audit belongs to the second-party audits, as the customer and the supplier are thus two parties involved. The performance of this type of audit is generally not mandatorily defined by sets of rules for all industries.

ISO 19011 provides the basis for conducting internal and supplier audits and regulates the systematic auditing of management systems. Nevertheless, as a guideline, the standard is only a recommendation. In addition to this, there is also the ISO 9001 quality standard, which represents an essential set of rules for supplier audits. There are also industry-specific standards, such as VDA 6.1 in the automotive industry. Among other things, these quality standards specify audit criteria for supplier audits. Third-party audits can also be certification audits. In this case, neither the customer (second-party) nor the supplier company (first-party) is responsible for conducting the audit. The auditing is carried out on behalf of the customer by an independent and external third party, for example a certification company. An independent audit is carried out by the auditing organization to check the management system for conformity to the standard. Its main task in the certification audit is to achieve the maintenance of the certificate or the granting of the certificate.

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A supplier audit is therefore a systematic monitoring of a supplier that the customer initiates to determine whether the quality management is suitable and to what extent it is implemented to meet the customer's requirements. It represents a supporting element to guarantee the assurance of the upstream supply chain in terms of the supplier's ability to provide the products or service and the correct quantity to the customer at the right time and with the specified quality. Audits are also conducted to support supplier selection and evaluation with results and findings. Among other things, an audit can also be used for the initial assessment of a supplier as part of the preselection process, but it is also used to audit existing suppliers for supplier controlling purposes. (Janker, 2008)

Furthermore, in addition to monitoring compliance with the existing condition, an audit should also aim to continuously improve the processes and procedures (Helmold and Terry, 2016). For this reason, supplier audits are increasingly being carried out to identify potential for improving performance and quality.

Supplier audits require mutual trust in any case, as company-specific know-how and internal company information are disclosed. Hence, supplier audits are often viewed from a critical perspective. Therefore, a contractual basis between the customer and the audited company is recommended. The supplier is generally not obligated to permit an on-site audit, which is why the customer should be granted the right to do so. To ensure confidentiality, a non-disclosure or confidentiality agreement between the parties is recommended.

Not only the customer, but also the supplier can gain valuable insights from these supplier audits. They can prepare for possible audits by a certification company, improvement potentials are uncovered and can be implemented promptly to increase the quality level or even reduce costs. (Wagner, 2002). In addition, the supplier learns to understand the needs of his customers much better and can respond to them in a targeted manner, which in turn can contribute to a competitive advantage (Obmann, 2014).

As the auditing process involves a great deal of work for all the institutions involved, care should be taken to conduct an audit only for those suppliers for whom the supplier's performance is of great importance to the procuring company. This applies above all to critical or very complex products. The supplier audit can be carried out either by the

customer personally or by a qualified person or company. The latter opens the possibility of reducing or even avoiding long journeys and additional effort, thus saving costs. This reflects one of the reasons why the way audits are conducted is changing. Thanks to modern technology, remote audits are possible nowadays, with auditing being carried out via interactive means of communication.

In this context, however, it should be noted that special attention should be paid regarding the information security and confidentiality requirements that must be met. This primarily concerns data integrity. Mention should be made here, for example, of faked data from suppliers that can hardly be verified at present with the tools available, or data leaks that can have consequences that threaten the existence of the company. For example, not all information and communication tools are suitable for use in remote audits. General regulations, such as the EU Data Protection Regulation (EU-DSGVO) on the processing of personal data, also play a significant role regarding data security.

Unfortunately, it must be stated in this context that complete security is currently not technologically feasible. In this context, standardization bodies will have to implement mandatory standards for remote audits to ensure high data quality and security, stable IT infrastructure and knowledge of people involved in the audit process. In 2018 the International Accreditation Forum (IAF) already provided a mandatory document for the use of information and communication technology for auditing purposes, called IAF MD 4:2018. The scope is to provide a standard for the consistent application in auditing and for the usage of information and communication technology within the audit methodology. Additionally, IAF offers further standards like IAF ID 12 (Principles on remote audits). Both are compatible with ISO standards for conformity assessments (Third-party). Therefore, the target should be to derive aligned standards for second-party audits as supplier audits in industry by standardization bodies.

3 Existing Research on Augmented Supplier Audit

Remote audits presuppose industry-ready hardware devices and technology. Due to the Garnter Hype Cycle AR technology is finally ready to go from pilot to productivity in enterprise space (Herdino, 2021). AR is described as extended or enriched reality since

the fading in of digital information leads to a fusion of reality with non-real content. The enrichment by virtual objects takes place continuously and makes it possible to adapt the representation to the current viewpoint of the respective viewer (Broll, 2013).

AR can be realized on various hardware devices such as smartphones, tablets, notebooks, or smart glasses and offer a wide range of applications from playful to highly technical applications such as the head-up display (HUD) in vehicles. (Peddie, 2017) (Mehler-Bicher, Reiß and Steiger, 2011)

The scope of AR applications in industry is varied. Employee training, support issues or simple visualization of data are just a few applications which are already implemented in industrial area. (Peddie, 2017) Especially sales specialists see high potential in the visualization of products as part of the customer service which leads to a highly innovative view on products and services (Ludwig and Reimann, 2005).

Research also shows high potential for AR in supplier audits. In past, remote audits of suppliers were already part of the business for third party-audits, whereby due to low efficiency and technical limitations such remote audits are not seen as feasible method. Nevertheless, with the augmentation of supplier audits, modern technology and industrial-ready hardware devices like data glasses enables companies to audit suppliers in a new way.

The following section presents research on the feasibility of augmented supplier audits. In a comprehensive literature review, AR technology was analyzed to understand the technology itself and check the possibility for application of AR-ready hardware devices like smartphones, notebooks, or data glasses in selected supplier audit process steps. Subsequently, based on the literature research two relevant types of augmented supplier audits were identified. Both deal with the development of an augmented supplier audit supported by AR technology and are based on the selected standard process of supplier auditing showed in Figure 3.

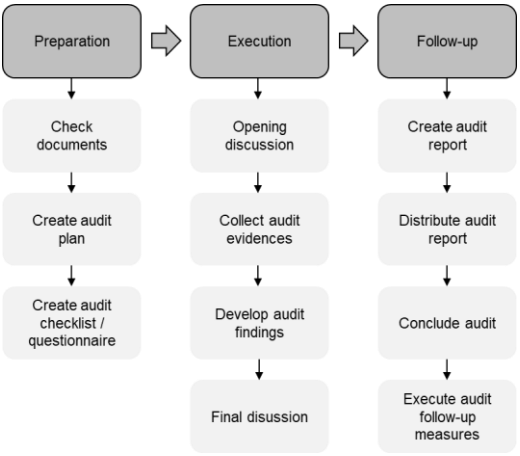

Figure 3: Process of Supplier Audit (Kallmeyer, 2019)

Firstly, before preparing the audit, it is crucial to define, resources for the execution of the audit, objectives, criteria, and the extent. During this preparation phase, the auditor must decide with the concerned supplier, which type of augmented supplier audit should be executed. Both types will be explained by using phase 1 (preparation) and 2 (execution) of the supplier audit process, which were identified as phases with high potential for AR technology support.

3.1 Augmentation of On-Site Supplier Audits

In this type of augmented supplier audit the auditor from the buying company is physically present at the supplier's production site. Especially in the supplier selection phase, approval as well as detection and monitoring of weaknesses in the process of existing suppliers, this type of audit should be preferred. (Kallmeyer, 2019) (Janker, 2008) The main objective of AR in this type is to achieve greater efficiency in the auditing processes.

Based on the literature research on augmentation of on-site supplier audits, following functions supported by AR devices could be identified. The functions are allocated to elements out of the audit process mentioned before.

Table 1: Identification of AR Potential in On-Site Supplier Audits

Element	Function	Device
Display company information	Overview of augmented processes, organizational charts, handbooks, certifications, and other related information for the audit process. Essential information can be marked as relevant to retrieve in the final discussion. (Kallmeyer, 2019)	Smartphone, tablet, notebook, data glasses
Augmented plant inspection via remote	Navigation of the auditor by using defined paths displayed directly on the floor to be guided to marked checkpoints of the audit process. (Shen, 2013) (Tönnis, Plecher and Klinker, 2013)	Smartphone, tablet, notebook, data glasses, helmet
	Emergency routes and hazardous areas can be marked to ensure safety measures during the audit process. (Khakurel, Melkas and Porras, 2018) (Peddie, 2017)	Smartphone, tablet, notebook, data glasses, helmet
Collect audit evidence	A list of available interview partner can be called up quickly. (Kallmeyer, 2019)	Smartphone, tablet, notebook, data glasses, helmet

Final discussion	The marked information in the company documents can be called up for final discussion of the supplier audit.	Smartphone, tablet, notebook

Main advantage of this type of supplier audit is the direct contact with the supplier. Though the auditor is on-site, costs can be saved by reducing the personnel expenditures. Experts from different areas do not have to join physically. Displaying relevant information as well as guiding the auditor through the production site are seen as main advantages and potentials to reduce audit times.

3.2 Augmentation of Remote Supplier Audits

The remote supplier audit is defined as fully remote audit without delegating an auditor to the production site of the supplier. The objective of this type is to reduce travel and time expenses for short audits in far off countries. This type of audit can be combined with the on-site supplier audit to ensure the interpersonal relation and communication. Therefore, headquarters can be audited on-site, while relevant secondary plants can be easily audited by remote. (Kallmeyer and Kretschmar 2019) (Kallmeyer 2019)

Table 2 shows the identified AR supported functions for remote supplier audits allocated to the supplier audit elements.

Table 2: Identification of AR Potential in Remote Supplier Audits

Element	Function	Device
Display company information	Overview of augmented processes, organizational charts, handbooks, certifications, and other related information for the audit process. Essential information can be marked as relevant to retrieve in the final discussion. (Kallmeyer, 2019)	Smartphone, tablet, notebook, data glasses
Augmented plant inspection via remote	The selection of certain areas/processes which should be specified by related persons to get further information. (Caricato et al., 2014) (Ludwig and Reimann, 2005)	Smartphone, tablet, data glasses
	Navigation of the auditee by using defined paths and easy changing of the defined path. (Chung, Pagnini and Langer, 2016)	Smartphone, tablet, data glasses
	Additional information or notes can be displayed directly in the viewing area of the auditee to easily check them.	Smartphone, tablet, notebook, data glasses
Collect audit evidence	The interviews with available employees can take place by using the remote connection. The device is used for image and audio transmission. (Kallmeyer, 2017)	Smartphone, tablet, data glasses
Final discussion	The marked information in the company documents can be called up for final discussion of the supplier audit.	Smartphone, tablet, notebook

The execution of remote supplier audits is linked to operational requirements. A stable internet connection as well as secure and reliable data transmission are mandatory to ensure an uninterruptable supplier audit. Therefore, infrastructure plays an important role. Hardware devices must be available on supplier-side, the supplier is entrusted with it and is able to use software and hardware efficiently. The substantial advantage is that the auditor has not to be physically at the supplier. Therefore, audit times can be reduced, several suppliers can be audited spontaneous and randomly. (Kallmeyer, 2019)

This leads to a higher comparability between the audit results for supplier benchmarking. It also requires suppliers to be trained sufficiently for executing augmented remote supplier audits. AR is seen as final enabler of remote audits. Until now, remote were understood as bilateral communication by using collaboration platforms like *Microsoft Teams* or other data sharing platforms. On the one hand by using AR technology, auditors can additionally be guided through productions sites by using portable and ergonomic devices. But on the other hand, remote supplier audits are not an equivalent substitute for supplier audits. Personal contact and advanced insights as part of a holistic supplier audit cannot be achieved in remote supplier audits.

4 Definition of an Augmented Supplier Audit Use Case

Based on the investigation of AR potential in supplier audits, the target was to define an industrial-suited augmented supplier audit use case. Therefore, both types of augmented supplier audits were analyzed in a subjective benefit analysis on different categories. Within this analysis essential hardware/technology and software was evaluated. These categories were selected based on the information gathered in the literature research and are seen as basic elements of augmented supplier audit. The target of the use case was to check the feasibility of augmented supplier audits in the industrial area and derive further research fields in this area. The focus of the use case is on data glasses, which enable an ergonomic and efficient supplier audit process. The evaluation and definition of the use case is a four-stage approach visualized in Figure 4,

whereby the last stage is including exemplary audit plans based on the production processes in the Smart Production Lab and is not mentioned in this paper.

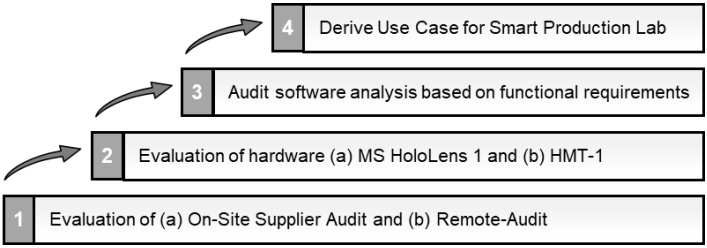

Figure 4: Structure of Subjective Benefit Analysis for Use Case Creation

The lab is part of the infrastructure of the University of Applied Sciences JOANNEUM and is used as research lab for Industry 4.0 and digitalization use cases. Within the lab different machinery is vertically integrated from the ERP (Enterprise Resource Planning) system to automation level, creating data by producing a customizable clock. The use case should enable the project team to simulate a supplier audit, whereby the Smart Production Lab is seen as the supplier.

The structure and the results of stage 1 to 3 are described in the following sub chapters.

4.1 Evaluation of Augmented Supplier Audit Type

In the first stage both types of augmented supplier audit, explained in the previous chapter are compared and evaluated by following criteria, which are based on literature research and experience of research project members in practical test runs.

Table 3: Evaluation Criteria for Use Case Selection

Criteria	Explanation
Audit Output	The objective of the audit is to collect as much relevant information as possible. Therefore, the audit output describes the audit evidence density generated during the audit process.
Soft Facts	Soft facts are as important as processes and KPIs to get general impressions. Corporate culture, HSE (Health, Safety and Environment) or 5S concepts are often recognizable as soft facts.
Audit Availability	This criterion evaluates the possibility for uncomplicated and rapid execution of supplier audits. In extraordinary situations business trips are not possible immediately due to resources and planning of audits.
Audit Costs	To execute supplier audits costs in sense of personnel and travel costs incur for the auditor. The costs are evaluated subjectively by researching the impact of the audit type on the overall costs of auditing.

Based on this evaluation criteria and the information gathered from the literature review, the following selection criteria were created. The pugh matrix method is the basis for weighting the criteria and was also selected for evaluations presented in the following chapters. In the next step the project team did a subjective evaluation based on the experience of first field tests and the knowledge out of the literature analysis. The higher the score, the better the result. This means, that “Audit Costs” are ranked higher in the category of low costs. In general, the evaluation is based on a scale from 0 to 10, whereby the value 10 represents an excellent score. The method of pugh matrix is also

recommended to management within the evaluation phase to ensure a profitable use case.

Table 4: Subjective Evaluation of Augmented Supplier Audit Types

On-Site-Audit / Remote Audit	Weighting [%]	Evaluation On Site / Remote	Score On Site / Remote
Audit Output	25	8 / 5	200 / 125
Soft Facts	15	9 / 3	135 / 45
Audit Availability	30	4 / 9	120 / 270
Audit Costs	30	4 / 7	120 / 210
Result	100		575 / 650

For an augmented supplier audit use case, the remote audit is selected as best fitting type due to its potential in terms of audit availability and costs. Doubtless the decrease of soft facts impressions and audit output must be considered anyhow in the audit report. The evaluation of hardware and software in the following stages is based on the requirements of the remote supplier audit.

4.2 Evaluation of Augmented Supplier Audit Hardware

The augmentation of supplier audits posits high-performance hardware for industrial usage. Therefore, two different hardware devices were tested in the Smart Production Lab, which enables industrial conditions for practical tests. With the *Microsoft HoloLens 1* and the *Realwear HMT-1* the Smart Production Lab provides state-of-the-art hardware devices which are suitable for industrial use. The main difference of both devices is the

technology. While *Microsoft HoloLens 1* supports Virtual Reality (VR) applications, *Realwear HMT-1* is based on Augmented Reality (AR) technology. Based on initial experiences with both devices, the following criteria were defined for a comparison of the AR hardware.

Table 5: Evaluation Criteria for Hardware Selection

Criteria	Explanation
Durability	Considers the industrial readiness. Especially IPC (International Protection Code) certifications or ATEX (Atmosphères Explosibles) explosion protection as well as durability in risk of falling are important characteristics for industrial usage.
Intuitiveness	Describes how the devices are controlled. Data glasses are based on different technology like gesture or voice control. Different disturbance factors may have an impact on the device control. Industrial background noises or unfavorable incidence of light could complicate handling.
Applications	The operating system (OS) determines the availability of applications in specific app stores of the OS providers. Comparable to the usage of applications on smart watches, not each app is ready for data glasses usage and may require specific adaptions and developments.
Hardware	The technical specification of the device. Conditions for the technical realization of augmented supplier audits include high data storage capacity, long battery life and enough sound and visual quality for video communication.

The evaluation and practical tests of *Microsoft Hololens 1* showed that VR technology is not relevant for supplier audits. Firstly, the creation of a fitting supplier audits use case supported by VR presupposes a strong relationship between both partners as well long preparation and development time. Due to comprehensiveness of the research, VR is evaluated and tested anyway. The subjective evaluation based on technical specifications practical experience is listed in Table 6.

Table 6: Subjective Evaluation of Hardware

HoloLens 1 / HMT-1	Weighting [%]	Evaluation HoloLens / HMT	Score HoloLens / HMT
Durability	20	4 / 9	80 / 180
Intuitiveness	25	7 / 7	175 / 175
Applications	30	2 / 8	60 / 240
Hardware	25	8 / 7	200 / 175
Result	100		515 / 770

Particularly the durability as well as the variety of applications are the main differences of both hardware devices. While *Microsoft HoloLens 1* is neither featured with ATEX certification nor IPC, *Realwear HMT-1* is designed for industrial usage by IP66 (dust protection and resistant to hose water). Furthermore, the *HMT-1Z1* is certified for ATEX zone 1 for oil, chemical, gas, or other industries. As this device works on an Android operating system, the *Google Play Store* offers many different applications for *Realwear HMT-1*, while *Microsoft HoloLens 1* operates on *Windows 10 platform*. The operating system is an important factor in this context because the app stores for each operating

system and consequently the availability of applications differ. With the release of the next *HoloLens generation (HoloLens 2)* the development and support of many applications has ceased for *HoloLens 1*. For the mentioned reasons, *HMT-1* is selected as the preferred hardware for further research.

4.3 Evaluation of Augmented Supplier Audit Software

As mentioned before, depending on the OS the user can download applications from different app stores. Since many applications are not optimized for the usage on data glasses devices, the number of appropriate solutions for augmented supplier audits is strongly restricted. Most of them are typical video conference of business communication platforms which were already used before AR for remote audits. To create an efficient augmented supplier audit process, applications with focus on core processes of supplier audit are needed. For example, for augmented maintenance, software developers provide a lot of solutions for AR devices.

Nevertheless, existing, and available applications were analyzed in a 2-stage approach to identify three software applications for further research. Table 7 shows an overview of functional requirements of the audit processes as well as compatible software applications usable on *Realwear HMT-1*. Marked cells indicate if the software application meets the requirements. The requirements are not ranked and are simply illustrated to show the most important functionalities of such compatible software applications.

Table 7: Market Screening of Applications for Augmented Supplier Audit (Extract)

Functional Requirements	Evocall	Teamviewer Pilot (TVP)	RISE	Skylight	blitzz
Live Communication	x	x	x	x	x
Send documents	x	x	x	x	

Functional Requirements	Evocall	Teamviewer Pilot (TVP)	RISE	Skylight	blitzz
Live instructions			x		x
Frozen instructions	x	x	x	x	x
Dynamic 3D instructions		x			
Share screen			x		x
Chat function	x		x	x	x
Communication History	x		x	x	

Based on the market screening, *Evocall*, *Teamviewer Pilot* and *RISE* were selected for further practical tests. These applications are available for *Realwear HMT-1* and support the functional requirements “Live Communication”, “Document Sending” and “Frozen Instruction”, which allow to guide through the audit process, offering and sending audit documents or recording video sequences or photos for further audit evidence and final discussions. These functionalities were practically tested by the research group and evaluated based on following criteria. Furthermore, these applications are already available in the Smart Production Lab infrastructure. For further research in industrial environment, it is recommended to enlarge the list of software applications. It is expected, that software developer will offer new features for audits soon based on the current need of industry.

Table 8: Evaluation Criteria for Software Selection

Criteria	Explanation
User friendliness	Describes the technical and functional user experience. This criterion shows the efficiency in usage as well as the prevention of operating errors. It concerns the hardware user view as well as the auditor view, who is steering the audit by using respective software.
Functionality	Describes how the technical requirements are solved by the application and which assorted specifications are provided. Screen sharing, creation of protocols or create other audit evidence are possible functionalities.
Costs	The evaluation of costs may be different in each company depending on the need and usage in other areas. In this case, the evaluation is based on a single case principle, which means that this use case is the only one which is executed. This fact reduces the need of licenses to a minimum.

After evaluating the practical experience made in the software tests, *RISE* was selected as most suitable software for augmented supplier audits. *RISE* offers remote zoom functionality, laser pointer, screen sharing, history of data transfers and report export functionalities. The final evaluation is listed in Table 9, showing advantages of *RISE* in all criteria.

Table 9: Subjective Evaluation of Software

Evocall / TVP / RISE	Weighting [%]	Evaluation Evocall / TVP / RISE	Score Evocall / TVP / RISE
User-friendliness	30	5 / 6 / 8	150 / 180 / 240
Functionality	50	8 / 5 / 9	400 / 250 / 450
Costs	20	3 / 6 / 7	60 / 120 / 140
Result	100		610 / 580 / 830

The functionality of *Evocall* and *RISE* is quite similar, the costs for software licenses are based on different pricing models. While *Evocall* offers single-client licenses, *RISE* offers multi-user license with tiered pricing. Nevertheless, the overall costs of *RISE* are evaluated better in the research.

The project team and authors were able to identify further potentials in each stage of the research. In the final use case, the Smart Production Lab represents the supplier's production site, which should be audited within the augmented supplier audit. The idea behind the use case is to show especially small and medium-sized enterprises (SME) new possibilities triggered by modern technology in daily business. New findings in this topic are presented to managers as well as to students within the courses of the University of Applied Sciences JOANNEUM. The feedback on prior and actual insights is thoroughly positive, whereby further research fields arise from this use case.

5 Further Research and Outlook

It is undisputed that the rate of digitization has increased manifold in recent years and is having an enormous impact on generating a competitive advantage at many different corporate levels. This development also affects auditing, and it is fair to assume that the proportion of AR audits will continue to rise in the future. Companies are continuously evolving and digitizing their process flows. It is clear to see that auditing will not be exempt from this. The authors of this article therefore recommend dealing with this topic at an early stage to gain greater experience in this area. The current COVID-19 pandemic has highlighted how relevant and useful remote AR auditing can be. As the Gartner Hype Cycle illustrates, AR technology should reach the next phase and emerge from the valley of disillusionment and be further developed accordingly so that it can then actually be used in companies in a way that adds value. Although remote audits are an excellent alternative to on-site audits, the authors do not believe that they will be able to completely replace them in near future.

However, AR has sufficient potential to make supplier audits more efficient and thus reduce the use of resources.

At this point, however, it should be noted that not all information and communication tools are suitable for use in remote audits. Special emphasis should be placed on legal concerns relating to information security requirements and confidentiality, which must be met. These are, for example, security aspects regarding data protection, image rights or the prohibition of recordings. Unfortunately, it must be stated in this context that complete security is not technologically feasible at present. This also applies to faked data, which could be generated by suppliers.

In conclusion, it can be said that the use of remote audits has both opportunities and limitations, and, depending on the situation and requirements, it is necessary to weigh up whether a remote audit is a suitable method for conducting audits. However, due to the current digital transformation and the crisis-induced switch to virtual tools, it can be assumed, as mentioned at the beginning, that remote audits will become increasingly popular in the future. (Fridl, 2020)

6 Concluding Remarks

The research shows the increasing necessity for modern supplier audit processes. Based on this fact, AR technology is arriving in supplier management now. Especially current disruptions in supply chains as well as sustainability aspects require substantial amounts of time and extra processes to induce cost saving measures.

As already mentioned in the use case, the integration of AR technology enables many advantages in the process of supplier audit. Whereby the need for standards concerning data privacy in supplier audits as well as for recommendations to ensure plant safety during the supplier audit is significant. Moreover, soft facts are a key omission in the fully remote supplier audit and are hardly replaceable in the process.

The created use case shows that many factors must be considered in the selection of software and hardware. Especially in the step of software selection, functional requirements should be known out of the defined audit process. The operating system of the hardware device could restrict the number of potential applications. Furthermore, software developers have not yet recognized the potential market of augmented supplier audits. Applications with interfaces in ERP or Supplier Relationship Management (SRM) systems are desired.

Concerning the hardware devices, auditors and auditees must ensure the availability of performing data glasses. The provision of hardware on the supplier's side may relate to export control regulations and could require temporary export authorization. Training employees should be part of a joint effort within supplier development measures. Business practice shows that companies are not yet ready for this transformation. Minimal standards and requirements for digitalization are not being fulfilled in the industry at the time of publication. A target-oriented usage of AR devices in supplier audits require these standards of digitalization to ensure an increase in efficiency of supplier audit processes.

Efficient augmentation of supplier audits not only ensure efficient processes, further advantages in supplier management can be realized. New auditing methods also

influence supplier selection as a further coverage of potential supplier market, which leads to more flexibility and risk reduction in sourcing.

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