Facility Services: Impact of new technologies

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Abstract

Studies estimate that in general 47 % of all jobs will be automated due to digitalisation. The Facility Service (FS) industry is the third largest sector in the EU. FS will be more affected as it consists of more routine tasks. The research questions are: Which technologies are relevant for FS and when are they feasible? Based on literature review authors evaluated relevant technologies/use cases. Expert interviews were carried out to validate the results. A survey was conducted to define technical and economic feasibility. The results present the relevant technologies and their feasibility in FS.

Keywords: Facility Management, Facility Services, Applications, Evaluations of new technologies.

1. Introduction and research questions

Facility Management (FM) is a key function in managing the demand and fulfillment of services and infrastructure necessary for the core business. Facility Management influences the ability to act proactively and meet all requirements of the core business. On the other side, it is to optimise the costs and performance of assets and services (Österreichisches Norminstitut 2007). Digitalisation impact Facility Management in two main areas:

Due to changes of the core business (new ways of working) the demand for infrastructure and services changes.

Digitalisation also has a big impact on the Facility Service (FS) provision: the application of new technologies, for example, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML) allow control over the complexity of FM processes and services in a more effective way.

The paper concentrates on the second area.

The outsourced FS industry is the third-biggest industry regarding of employment in the EU (Stopajnik & Redlein 2017). This makes the FS industry very important. Furthermore, it must be noted that services around buildings and infrastructure cannot be off-shored. FM-activities have a high significance for process optimisation (Chotipanich 2004). Therefore, the application of new technologies, like IoT, AI and ML becomes an important factor (Selinger et al 2013). The starting point of a large-scale implementation, of so called smart technologies, is that such technologies must provide some level of performance for specific applications before they will begin to diffuse (Čas et al 2017).

Many studies are analysing the impact of digitalisation on work processes. These studies assume that routine-tasks will be most affected and conclude that there will be drastic changes and shifts in required skills (Nagl et al 2017, Stopajnik & Redlein 2017a, Frey & Osborne 2018). The study of Frey and Osborne (2018) showed on how susceptible different jobs were to computerisation in the US. They estimated that 47% of all jobs would probably be substituted by computers. On basis of technological progress in machine learning, mobile robotics, they determined the probability of computerisation for over 700 occupations. Furthermore, the study of Stopajnik & Redlein (2017) shows the impact of digitalisation on the Facility Service Industry. They estimated that typical FS activities (Österreichisches Norminstitut 2007a) are at very high risk, e.g. Installation. Maintenance, repair work has a 50 % probability to be automatised, janitors and cleaners have a probability of 66 %, and first-line supervisors of housekeeping and janitorial workers show a probability of 94 %. (Stopajnik & Redlein 2017, Peneder et al 2016) to be automatised.

	EU	**US**
Total number of employees in Total business economy	135.601.377	90.337.386
Total number of employees in Facility Services	14.438.876	9.008.432
Proportion of employees in Facility Services	10.65%	9.97%

Tab. 1. Comparison between the numbers of employees for business economy in general and for the FS sector in the United States and the European Union, from 2014 (Stopajnik & Redlein 2017)

Existing research postulates that technological developments like IoT, AI, ML can help to fulfil FM requirements better and reduce costs in the same time. The existing studies give only a macro-economic view on the changes within FS. (Stopajnik & Redlein 2017, 2017a, Frey & Osborne 2018) But an estimation of relevant technologies and use cases/scenarios are needed to depict how these technologies will change the industry. The research objectives of this paper are to provide an evaluation of the relevant technologies, their application possibilities (case studies) and their technical and economic feasibility. The research questions are:

1. What technologies are relevant for optimisation of the Facility Service provision?
2. What is their technical and economic feasibility?

2. Methodology

The study is based on the Mixed Method Research Approach that combines quantitative and qualitative research methods. This means, the Mixed Method Approach combines quantitative surveys with qualitative data collection methods, e.g. personal interviews, expert groups, workshops with professionals and content analysis. The goals of qualitative research are induction, discovery, exploration, theory/hypothesis generation. The major goals of quantitative research are deduction, confirmation, theory/hypothesis testing, explanation, prediction using standardised data collection and statistical analysis. Quantitative and qualitative method have lack of strengths (Johnson & Christensen 2007). The goal is to draw from the strengths and minimize the weaknesses of both research methods (quantitative and qualitative) in single research studies and across studies. Taking a mixed position allows researchers to mix and match design components that offer the best chance of answering their specific (research) questions (Johnson et al 2007).

The used methodology consists of three steps.

1 Extended literature review was used to define the relevant technologies and generate use cases and scenarios. Scenarios created described future development for feasible using of new technologies for Facility Services.
2 A questionnaire was developed to define the technical and economic feasibility of the scenarios/technologies due to a survey. The quantitative study had the goal to validate the results of the qualitative steps done before.
3 Expert interviews were carried out to validate these scenarios. The survey was carried out in spring of 2017. 50 German-speaking facility managers from the healthcare industry were interviewed. The result was a list of smart building technologies and the estimation of their feasibility.

2.1. Literature review

A broad literature review was carried out to analyze and evaluate existing publications for potential use cases and forecasts of the changes due to digitalization in the sector focused. The first thread of thought ensured that the authors of the study would maintain a neutral perspective by finding as many studies as possible which dealt with operationalization of new technologies independently of theoretical traditions. The second thematic thread focused on the instructional perspective, since the authors were interested in business premises and properties of digital environments that might support facility services.

The two remaining threads restricted our search to technologies and applications in that context. The authors considered the fast pace of short product cycles and new technologies are being developed (Multi-Annual Roadmap 2018). It was expected that publications of technology companies and journals will be more important sources than those of books. Hence, the authors screened reports of following areas: Business project descriptions, press articles, promotion reports, evaluation reports (scientific & consulter), project descriptions from councils and communities. The authors searched empirical studies published in peer-reviewed journals with a publication date from January 2000 to February 2018. Digital Reports like IEEE Xplore digital library, Harvard Business Review or Researchgate were powerful resource for discovery of scientific and technical content published by institutes of technical engineers and its publishing partners. This procedure resulted in n = 350 records. The journal that was the most frequently represented was IEEE. The next step was to conduct short project description screen. To broaden the scope also cases from different industries were included in the analysis. This was done to enable Relocating: changes of the location and production methodology (Servatius 1985). In most articles, figures about the economic effects/benefits are based on the study of a single technology or one specific industry case. Different kind of usability in the use cases were gathered in the category of “services/domain”, 93 in sum. The data presented is not specifying in detail how the impact could look like. Existing data cannot be used for a general proof for the feasibility of use cases in the area of FS (Čas et al 2017). Therefore, relevant technologies and use cases founded in the literature were gathered.

The use cases were clustered according to:

- current service field, in which it is applied (Österreichisches Norminstitut 2007a)
- technologies used and
- technical and economic feasibility.

2.2. Use case validation

The results were presented to experts to validate the findings but also to develop new scenarios. The results gained, were the basis for a draft of use cases how new technologies can change the operation of buildings/infrastructure and service provision.

2.3. Survey

Based on the scenarios a questionnaire was developed and more than 50 facility managers of the health care sector were asked to evaluate the technical and economic feasibility of the use cases/scenarios and the applied technologies. In a highly regulated industry like healthcare, compliance is especially important. Guidelines set high standards in a cost-effective manner. (International Organization for Standardization 2001)

The data was entered in MS Excel and analysed. The basis of the used statistics was parameter distribution, i.e. mean, median and max of total answers. To understand the tendency of data and the underlying distribution of the data. Measures of central tendency, also known as measures of location, are typically among the first statistics computed for the continuous variables in a new data set. The main purpose of computing measures of central tendency is to give you an idea of what is a typical or common value for a given variable (Boslaugh et al 2008). The results are validated by questioning the outliers, retracements and changes in trends.

3. Results

Ten innovative technologies were identified from literature review (Chotipanich 2004, Selinger et al 2013, Nagl et al 2017)

- Sensors/Internet of Things
- Drones
- Augmented reality
- Virtual reality
- BIM
- Mobile apps
- RFID
- Robotic (cleaning/transport/security)
- Automation
- BIG Data

3.1. Feasibility of IoT

The first scenario elaborated was the IoT (Internet of Things), which enables objects to connect and to exchange data. For example, smart sensors are being used today in walls and floors to monitor temperature, structural integrity, and to control light systems. IoT includes “embedded intelligence” in individual items that can detect changes in their physical state. Sensors give things a “voice”: by capturing data, sensors enable things to become context-aware, providing more experiential information to help people and machines make relevant and valuable decisions (Selinger et al 2013, International Organization for Standardization 2001).

The methodology described above now applied to derive the technical and economic feasibility (years till feasibility) of IoT in FS.

The left column of Fig. 1 and 2 shows the results of the use case definition based on literature analysis and expert interviews. The applications of the technologies derived from step one and two were included in the survey. Afterwards the experts were asked to evaluate the technical and economic feasibility. Fig. 1 shows the answers for the technical feasibility, Fig. 2 shows the answers for the economic feasibility. The range of answers is described by using median (which are 0 years), mean and max of the answers (years till feasibility). The statistical data allows realistic feasibility estimation.

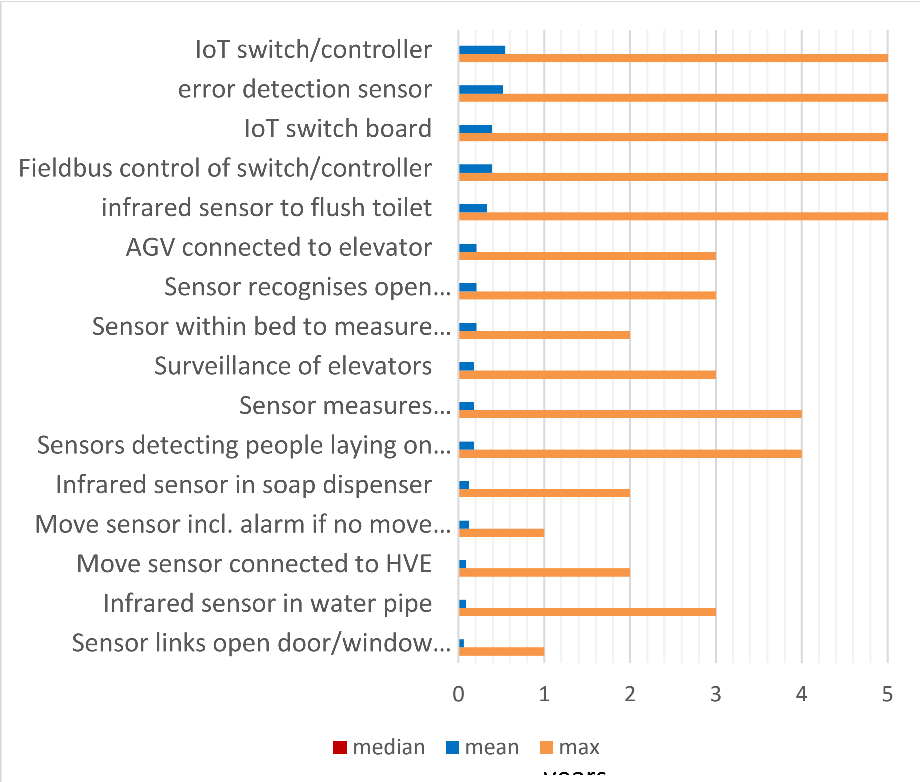

Fig. 1. Technical feasibility of Sensors/IoT in the FS sector (years till feasibility)

The experts estimated this technology as already technical feasible. IoT devices are able to produce the energy they need by themselves and those applications can be easily connected to the WIFI of the buildings, enables the use of IoT in addition. (Xu et al 2014) Hand dryers with sensors and move sensors are already in use and therefore technical feasible. Sensors, which recognises to open the door/window by sending message and infrared sensor to flush toilet show a short time till they are technical feasible. IoT switch/controller and IoT switch boards have a mean technical feasibility of around half a year. The answers show that IoT and IoT sensors have a short time till they are technically feasible.

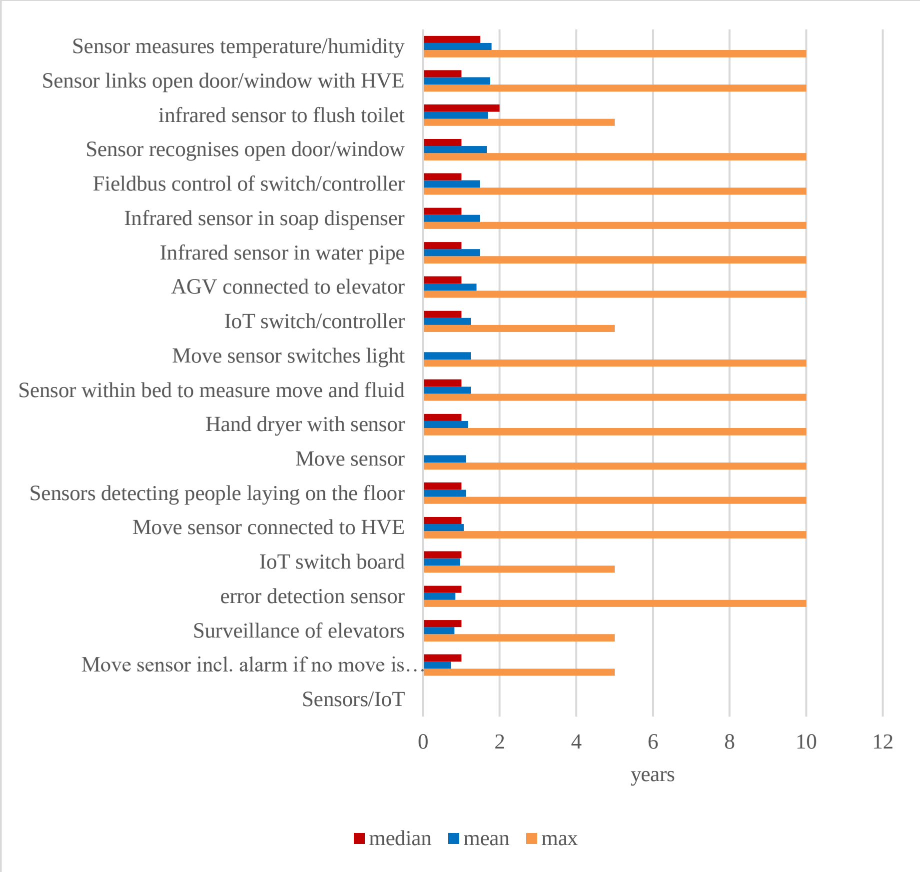

Fig. 2. Economic feasibility of Sensors/IoT in the FS sector (years till feasibility)

Fig. 2 shows the economic feasibility of sensors. Move sensors and surveillance sensor for elevators are already economic feasible. Whereas IoT devices measuring temperature/humidity, open doors and windows are still too expensive. (Kone 2018)

In general, IoT devices have the shortest technical and economic feasibility.

3.2. Feasibility of Mobile Apps

Mobile Apps were also evaluated to be highly realistic use cases for Facility Service (FS) provision.

Fig. 3 shows the technical feasibility of Mobile Apps. Order confirmation, failure message sending via apps, path finding and controlling room climate have a mean of 0,3-0,5 years.

Fig. 4. shows economic feasibility of Mobile Apps. Using apps to control room climate show a mean time to economic feasibility of 1,3 years and a median of 2 years. Order confirmation has a mean of 1,1 years, path finding and send failure messages show an even shorter time to economic feasibility. Statistical data analysis shows discrepancies between some estimations.

Many experts consider this technology to be applied soon, some believe it will take longer until this technology is technical feasible. This can be seen in the big differences between median values (which are 0 years),mean and max values.

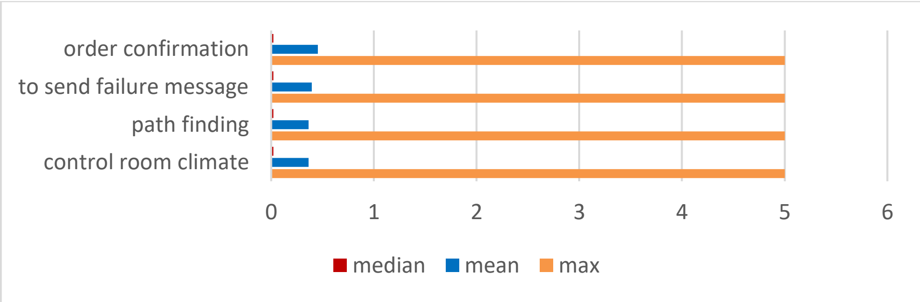

Fig. 3. Technical feasibility of Mobile Apps in the FS sector (years till feasibility)

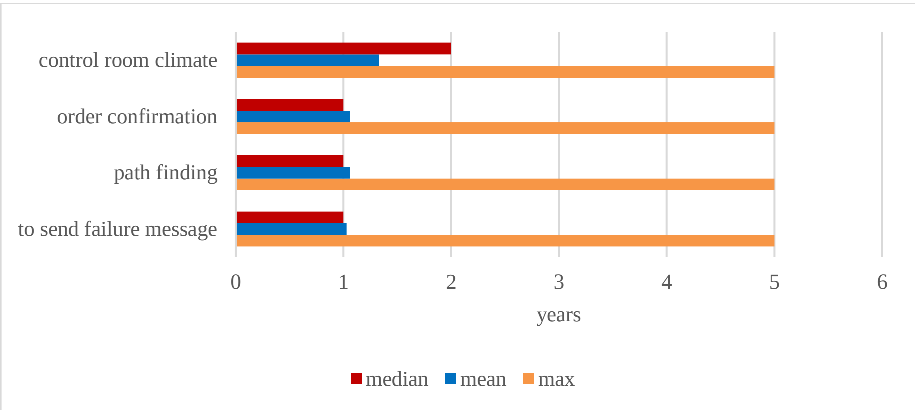

Fig. 4. Economic feasibility of Mobile Apps in the FS sector (years till feasibility)

In general, Mobile Apps are estimated to be technical in 0,5 years and economic feasible in about a year in FS operation. The reason for relatively high feasibility is that Mobile apps optimize the service of procurement. (Deloitte 2018) The economic feasibility is in all cases longer than one year, which is twice longer than the technical.

3.3. Feasibility of Drones and Robotic

Drones and service robots have been mostly restricted to providing benefits in repetitive applications. Robots working with consistent precision and repeatability. The future demands other capabilities – particularly in the fields of professional and consumer service robotics. If robots are to move into other fields they must become more flexible and provide benefits in a larger variety of situations. (Čas et al 2017, Multi-Annual Roadmap 2018)

Different use cases in FS provision like providing building maps, general or sewage inspections were found in literature research and named by experts. Fig. 5 shows the results for technical feasibility of using drone applications. Drone applications will be technical feasible in a range of 1-2 years and economic feasible in a range of 3-5 years. Providing building maps, general inspections and sewage inspections had a mean below 2 years. This technology provides affordable 3D maps of existing buildings and may lead to a change in the profession of architects and civil engineers, as these are the two professions providing as-build drawings. As these drawings are also the basis for CAFM tools, their usage possibilities may change also.

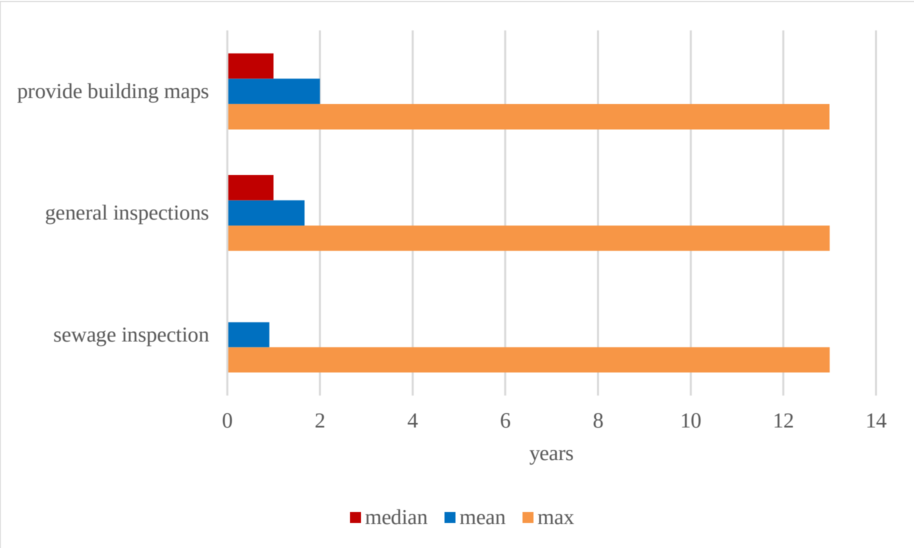

Fig. 5. Technical feasibility of Drones in the FS sector (years till feasibility)

The economic feasibility of Drones is shown in Fig. 6. The provision of building maps will be economic feasible with a mean of 3,5 years, general inspections with a mean of 2,5 years and sewage inspections with a mean of 2 year. Especially in the areas of inspection, Drones can optimise the service provision. Instead of human climbers doing the inspection of the roofs and outside of buildings Drones can deliver precise information about the conditions without endangering humans. AI tools can analyse the detailed pictures to diagnose first changes in the surface leading to major damages later. But the economic feasibility will take more than 2 years in average.

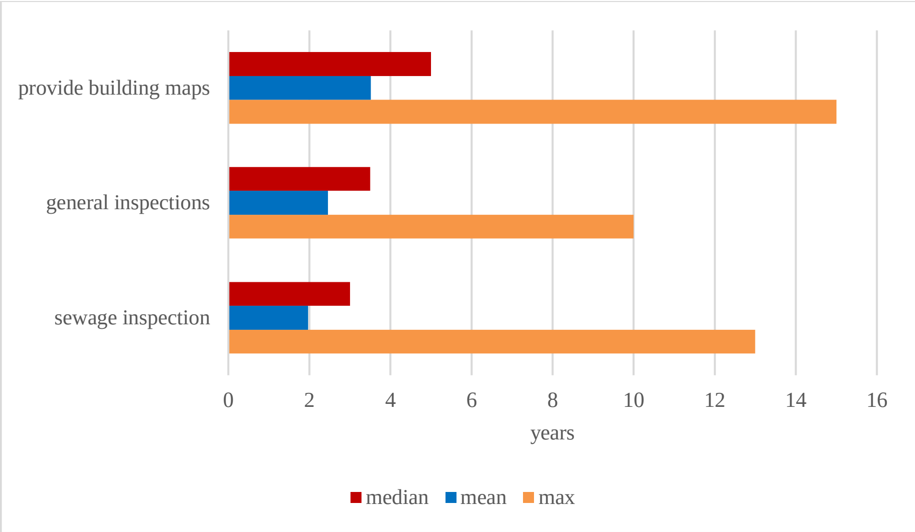

Fig. 6. Economic Feasibility of Drones in the FS Sector (years till feasibility)

3.4. Feasibility of technologies in general

Table 2 sums up findings from literature review, expert interviews and evaluation for all technologies analysed. Table 2 gives in the first column an outline about the relevant technologies in the area of FS operation (results step one and two). The second and third columns provide the mean timeframe of the technical and economic feasibility. Feasibility is measured in years till feasibility, which represents the results of the survey. Some applications of technologies are more likely to become technical and economic feasible than others.

To sum up, use cases of IoT will be feasible in shortest mean timeframe. Considerably evidence exists in the literature (Multi-Annual Roadmap 2018, Xu et al 2014). It will need 0-0,55 years to become technical feasible and 0,73-1,79 years to become economic efficient. Application of Mobile Apps is the second highly reasonable technology. It will take between 0,36-0,45 years till use cases of this technology become technical feasible, and 1,03-1,33 years that they become economic feasible. Robotics comes next, with a mean timeframe of 0,45-2,03 years to become technical feasible, and 1,33-3,91 years to become economic feasible. These examples could directly be used to optimise FS processes. Building Information Models (BIM) become technical feasible in a short time (0,33-1,09 years), but it would need a mean timeframe of 1,94-2,24 years that this technology becomes economic feasible.

The study shows that the most important technologies are Sensors/IoT, Mobile Apps, RFID and Robotics. Whereas, technologies like BIM, Augmented and Virtual reality require more time until they will begin to diffuse in the area of FS operation.

Tab. 2. Technical and economic feasibility of new technologies

Technologies	**Technical feasible** (mean timeframe till feasibility)	**Economic feasible** (mean timeframe till feasibility)
Sensors/IoT	0 – 0.55	0.73-1.79
BIM	0.33 – 1.09	1.94 – 2,24
Mobile Apps	0,36 – 0,45	1,03 – 1,33
Robotics	0,45 - 2,03	1,33 – 3,91
RFID	0,52 – 0,75	1,27 – 1,85
Digitalization / Automation	0.58 – 1.73	1.82 – 2.27
BIG Data	0.70 – 0.79	1.61 – 2.06
Virtual reality	0.91 – 1.00	1.82 – 2.42
Drones	0.91 – 2.00	1.97 – 3.52
Augmented reality	1.18 – 1.58	1.67 – 2.3

4. Conclusion and outlook

The literature review, the expert interviews and the survey accomplished show that digitalisation has a big impact on the Facility Service (FS) provision. Results show that most relevant technologies like IoT, Mobile Apps and Drones are already widely spread and technical and economic feasible. Connected Sensors can already be implemented in business processes, Mobile Apps will follow soon. Robotics is the next technology to follow. Other technologies like virtual and augmented reality will take longer till they can bring economic benefits. The results for RFID and BIM were unexpected as the literature presents them as technological feasible. The experts estimate a long time till these technologies are economic feasible. It also must be considered that some technologies are based on each other's. For example, augmented and virtual reality need a CAD or BIM model of the building that they can be applied. Therefore, producers of equipment provide alternative use cases like cloud maintenance guidelines that are provided through augmented reality technology. These use cases need a shorter period to be economic feasible.

Some applications of new technologies allow control over the complexity of FM processes and services in a more effective way. They disruptively change the way services will be provided in the future. They enable on demand service provision instead of scheduled or preventive task execution based on historic data.

In addition, dangerous tasks can be transferred to Robots or Drones. This study demonstrates a high potential for practical implementation of IoT, Mobile Apps and Robotics.

The research done also shows, that the effects of digital transformation on FS processes are not yet fully understood and will need further research. Most of the surveyed companies still use a lot of standard technology to cover FM processes and functions. Other technologies like AI, ML develop so rapidly that their usage possibilities cannot be evaluated properly. This postulates the need for further research and the application of technologies in practical use cases to prove especially economic feasibility. Based on this research and further studies the demand for training for the service employees also need to be estimated to enable them for the usage of the new technologies.

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