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Comparing Techniques for Selecting Automation Technology

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Abstract. Automation of industrial processes is a necessary step towards the Industry 4.0 vision. There are several justification techniques available that can help to improve chances for success in automation projects. A literature review on justification techniques and their usefulness is carried out. Based on the review, a set of criteria for evaluating justification techniques are developed. A case study is carried out in a company with an ongoing manufacturing system development project that includes decisions regarding processes and technologies that require a systematic evaluation and justification. Two justification techniques were selected and tested in the development project. The tests show that both justification techniques provide good support for the technology acquisition process. Strengths and weaknesses of the tested techniques are highlighted. The study suggests that the choice of method should depend on the type of acquisition process of a company, especially with respect to technology strategy, competences, and supplier relations.

Keywords: Operations strategy · Automation · technology acquisition · Justification techniques

1 Introduction

Manufacturing companies are forced to look for progressive automation technologies to keep their market share and maintain competitive [1, 2]. The capability of the companies competitiveness is essential for their survival [1, 3]. Automation technology has been the development key driver of processes in manufacturing plants since it entered the manufacturing industry [4, 5]. Implementing an automatic system can result in cost savings within production or increased efficiency, productivity and competitiveness [6, 7]. However, the introduction of automation technology will need time to achieve successive implementation [8, 9]. It is also important to be aware that automation can bring problems and failures and not necessarily immediate success [10]. Additionally, Frohm [8] states that increasing level of automation in unforeseen production situations can be

related to production disturbances, while Duncheon [11] list challenging cases like innovative products or products with short life cycle because of the uncertainty related to such production.

The development of manufacturing systems entail large investments, which will require justification of the decisions that are to be made [2, 4, 12]. The literature consists of many justification techniques for the acquisition of automation technology, but the use of such techniques in industry is limited. The existing techniques are criticised for being too time consuming, or not user friendly, or for putting too much weight on the financial aspects, or for a lack of sufficient support to the decision maker in certain phases of the selection process [3, 13-15]. There is a need to verify the usefulness of such methods in the industry [16, 17].

The purpose of this paper is identify two justification techniques that support the main phases of an automation technology selection process, to test these techniques in a case, and evaluate their usefulness in practice. The main contribution is a set of criteria for evaluating justification techniques, and insights about the usefulness of two justification techniques in industry.

The paper is organised as follows. First, the methodological approach is discussed. Next, the most common justification techniques is reviewed. Two techniques are applied and evaluated in a case study. Finally, conclusions are presented together with suggestions for further work.

2 Methodological Considerations

This study is based upon a literature review and a case study of an automation selection and acquisition process. The purpose of the literature was to investigate the main criteria for evaluating and prioritising justification techniques. Based on the review, a set of criteria for evaluating justification techniques is developed. An single case study approach was chosen to ensure enough detail and in-depth insights about actual use of justification techniques in industry. The case company was selected because they have an ongoing manufacturing system development project that include decisions regarding several processes and technologies that require a systematic evaluation and justification. Case company data was collected in several iterations over a year. Most of the data were collected in workshops with case company representatives. Interviews and discussions with key personnel were carried out combined with plant visits.

3 Theoretical Discussion

Chan et al. [1] classifies justification techniques into the three groups; strategic, economic or analytic approach which can be used unaided or combined. The combination of strategic and economic approaches is a common combination since the strategic approach has direct tie to the goals of the firm, and the possibility of overlooking the economical and tactical impacts gets covered by the economic approach [1]. The economic approach is based on an evaluation of the economic aspects and can contribute to the final decision of choosing an automation technology [1]. The strategic approach

involve analysis of competitive advantage, business objectives, research and development, and technical importance [1, 16].

3.1 Justification Techniques

The main phases that should be supported by a justification technique is technology strategy, analysis of operations competences and requirements, analysis of potential technologies, investments analysis, and implementation policy analysis [18]. The main justification techniques and their support for different phases are listed in Table 1.

Table 1. Justification techniques and the main phases they support.

References	Strategic	Operations	Technology	Investment	Implementation
Baines [13]	X	X	X		X
Chan et al. [1]	X	X	X	X	X
Chuang et al. [19]	X	X	X		
Durrani et al. [14]	X	X	X		
Efstathiades et al. [20]	X	X	X	X	X
Farooq and O'Brien [21]	X		X		
Iakymenko [22]	X		X	X	
Raafat [23]				X	
Sambasivarao and Deshmukh [2]		X		X	
Shehabuddeen et al. [17]		X	X		
Thomassen et al. [18]	X	X	X	X	X
Torkkeli and Tuominen [24]	X		X		X

3.2 Criteria for Selecting Justification Techniques

An utilisation of justification techniques can contribute to evaluate important areas when acquiring automation technology [1, 15, 25, 26]. The important areas can vary in the different techniques, which depends on their aim of support. However, it is essential that a technique contributes with enough support in the acquisition process [24], as well as evaluating the necessary area for the particular process [3, 13, 14, 24].

For a justification technique to be supportive in an acquisition of automation technology, it has to be applicable and well explained [13, 14, 18]. Such technique will be easy to follow and prevent unnecessary use of time or expertise. Effective techniques will reduce the time and work load for a practitioner. Additionally, production processes with special challenges will benefit justification techniques with the possibility of modifying evaluation areas [17, 24]. The most important criteria for evaluating the usefulness of justification techniques is listed in Table 2.

Table 2. Key criteria for evaluating the usefulness of justification techniques.

Category	Important elements	References
Ease of performance	Effective in execution	[2, 17, 18, 21, 24]
	Applicable	[13, 14, 18, 21]
	Well explained	[13, 14, 18, 21]
Covers necessary areas	Include the important areas	[1, 15, 25, 26]
	Ability to evaluate distinctive areas for the process	[3, 13, 14, 17, 24]
	Guides the selection part of the acquisition process	[2, 17]
	Guides multiple parts of the acquisition process	[13, 14, 18, 21]
Type of approach	Exclude the practitioner's "gut" feeling	[1, 15, 17, 25, 26]
	Combine strategic and economic approach	[1, 16]
	Prioritise technology alternatives	[2, 13, 14, 17, 18, 22, 24]
	Evaluate with a visualising model	[14, 15, 18]
	Evaluate with a scoring model	[15, 17, 22, 25]

4 Case Study

The case company is within the aerospace and defense industry. The company wants to automate a production line for medium and large caliber ammunition, where many operations currently are performed manually and several processes are very challenging to automate. Two justification methods were selected for testing. The APROS (Automation Project Selection) method [18] was chosen because it support all phases of a technology acquisition process. The technology selection framework [17] has a more limited scope, but were selected because it provides a set of scoring models that enables a thorough evaluation of a certain technology.

4.1 The Automation Project

The planned production line to be transformed into fully automated production line consists of stamping tracer and explosives (semi-automated), assembly (semi-automated), marking (fully automated) and packing (manual process). A mapping of the processes has shown that the assembly process seems to be the most challenging to automate, and a plan with milestones has been to automate the assembly process, Table 3.

Table 3. Milestones in the automation project.

Date	Activity
12. 2015	Project start in the production department
01. 2016	Tender sent for the assembly process
02. 2016	Meetings held with potential suppliers for the assembly process
03. 2016	Offers received from suppliers on the assembly process
04. 2016	Supplier selected for an automation technology in the assembly process
06. 2016	Order is placed for the selected automation technology on the assembly process
05. 2017	Automation technology for the assembly process is implemented
07.2019	The production line is fully automated in the manufacturing company

4.2 The Evaluation of Technologies

The automation technology offers received from three different suppliers were evaluated with the two justification techniques in the case study. The first offer, technology alternative 1, consists of robots processing and transferring one product at time between the stations. The second offer, technology alternative 2, consists of transporting pallets with multiple products. In addition, the input is handled by a robot and navigated with a camera solution. The last offer evaluated, technology alternative 3, consists of an input with a blister and transports multiple products with pallets. The practitioner picked out three parts of the assembly process for evaluation, which were the three most important parts in the assembly process to be supported by techniques. Three processes in assembly were selected for evaluation, 1) materialhandling between work station, 2) feeding components to a station, and 3) gluing and control.

Table 4. Results of the technology evaluation.

Part of the process	Selected alternative in the first technique	Selected alternative in the second technique
Intern transport	Technology alternative 1	Technology alternative 3
Input	Technology alternative 2	Technology alternative 3
Glue applying and control	Technology alternative 1	Technology alternative 3

The more strategic evaluation performed by the APROS method suggested that the company should select technology 1. The second justification technique gave scores with very small deviations (technology 1: 6,1, technology 2: 5,7, and technology 3: 6,4). The final decision was therefore to go for technology 1, with robots processing and transferring one product at time between the stations.

5 Discussion

The two justification techniques point out different solutions, but the differences between the results of technologies are not so different with a closer look. The results are

in close race in both of the techniques for each process, which make all results from the justification techniques valuable. The evaluation of the usefulness of the justification techniques is summarized in Table 5.

Table 5. Evaluation of the techniques based on evaluation criteria.

Category	Criteria	APROS	The tech. selection framework
Ease of performance	Effective in execution	X	X
	Applicable	X	X
	Well explained	X	
Covers necessary areas	Include the important areas	X	X
	Possibility to include additional areas		X
	Guides one part of the acquisition process		X
	Guides multiple parts of the acquisition process	X	
	Exclude the practitioner's "gut" feeling		X
Type of approach	Combination of strategic and economic approach	X	X
	Evaluate with a visualising model	X	
	Evaluate with a scoring model		X

Both justification techniques provides good support for a automation technology acquisition process. The APROS approach is suited to guide the complete acquisition process from establishing strategy to investment in technology. The APROS methodology supports multiple parts of the acquisition process, and this makes it possible to use the technique in different areas dependent on the practitioner's requirements. It is visual, highly effective, easy to understand, and evaluate important areas of the technologies. However, it should include earlier experience with the suppliers and their reputation, and does not explain the cost calculations well enough. The technology selection framework, only supports the core selection process in the acquisition of an automation technology. It is based on a detailed scoring model and is a more thorough justification technique. However, it is difficult to understand at first. It does not explain the meaning of the scores in the model, which made the practitioners insecure of how to understand the score scale. The cost calculations are not explained well enough. The choice of method therefor depends on the type of acquisition process a company is performing, and how well the technology strategy, competences, and supplier relations are established in the company.

6 Conclusion

This paper reviews justification techniques and test how such methods perform in practice. The main contribution is a set of criteria for evaluating justification techniques, and some insights about the usefulness of two justification techniques in industry. The application of two techniques in a case study showed that both techniques has strengths and weaknesses, and their applicability depend on the purpose and manufacturing environment for a technology acquisition process.

Further work should be done to test justification techniques and evaluate their usefulness in case companies that has different technology challenges and manufacturing environments.

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