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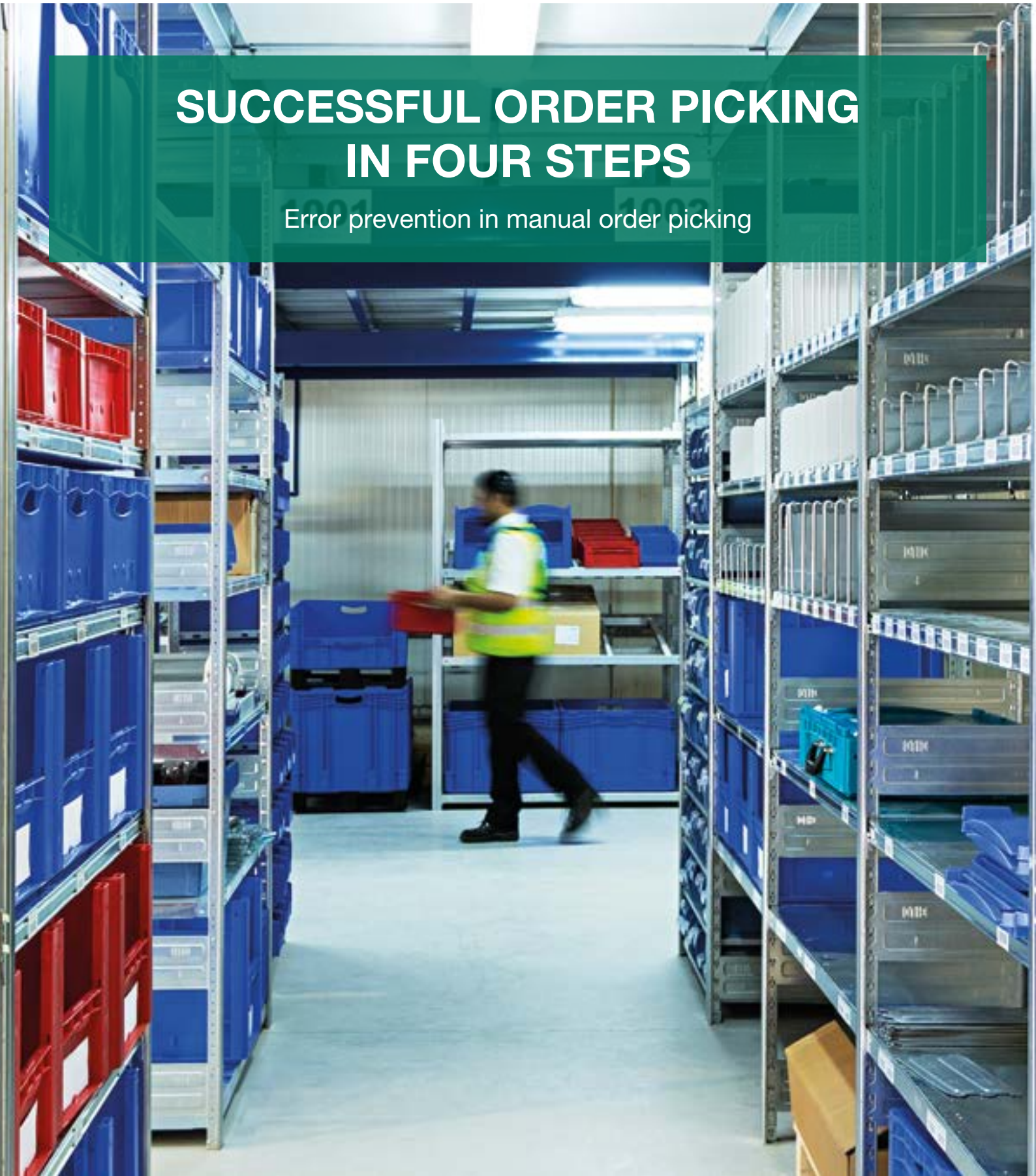
WHITE PAPER

SUCCESSFUL ORDER PICKING IN FOUR STEPS

Error prevention in manual order picking



Interactive trade with material and digital goods is growing continuously and has established itself as an independent industry, especially in the past few years. In Germany, interactive trade rose from about EUR 50.2 billion and a retail share of about 10.9 % in 2014 to about EUR 52.4 billion with a retail share of 11.7 % in 2015.[1]

Within that sector, online mail order business in particular continued to develop very positively. In 2014, the pure online retail share amounted to about EUR 43.45 billion and rose to EUR 49.62 billion in 2015 for the first time according to a study.[2] This corresponds to a growth of approximately 14 %.

About every tenth euro in Germany is spent online.

At the same time, more and more classic and specialist mail order dealers are investing in the expansion and further development of their logistics activities, specifically in the in-house logistics of their companies. An essential part of these investments flows into the continuous development of order picking systems for managing order and article growth.

This also influences the cost structure within companies. In the overall context, the share of in-house logistics in the total logistics costs lies between 10 and 50 %. Order picking accounts for about 50 % of the costs.[3] In the case of online trade, manual order picking is used most frequently as the main logistics function, resulting in high flexibility and low investments. In addition to the low order picking performance in comparison with automated systems and mistakes caused by human error, the high, manual deployment of personal resources can be seen as a disadvantage in this case.

In view of the time from the receipt of the order till dispatch logistically speaking, the problem-free functioning of an order picking system is a decisive factor for success. Mistakes resulting from order picking errors can have a very fast and strongly negative influence on the profitability of mail order businesses and are frequently underestimated cost drivers.[4]

In addition, order picking errors also influence order quality because, for example, ordered goods do not reach the customer or the delivered shipment does not contain the ordered goods. The resulting costs, e.g. for returns or subsequent deliveries, can negatively influence the profitability of the mail order business – especially if an error that affects the customer is discovered. If such errors frequently happen, the image of the business can be damaged and customer satisfaction can decrease.

It becomes clear that the implementation of suitable strategies for preventing errors in order picking systems can make a decisive contribution to the economic success of mail order businesses. In this way, costs can be lowered, quality increased, and the time from the receipt of the order to dispatch reduced.

[1] Cf. bevh 2014
[2] Cf. bevh and IFH 2014
[3] Cf. Spee 2005
[4] Cf. Rammelmeier, Galka and Günthner 2012

Order picking in logistics systems are extremely important within in-house logistics processes as order picking represents the requirement-based connection between the warehousing function on the one hand and the consumption function (e.g. production, shipping) on the other.[5] In addition, order picking is a considerable cost factor within the company. The share of in-house logistics in the overall logistics costs lies between 10 and 50 %. Order picking accounts for about 50 % of the costs. This underlines the importance of order picking within the company and in the overall logistics process.

Order picking describes the compilation of a required quantity of one or more articles for a customer. The compilation is called an order and the process is called order picking. Order picking is thus the requirement-based order assembly of articles for a customer order and its packing and provision for transport.[6]

The retrieval process is the core of order picking. In this case, the required articles are picked from a certain storage location or load carrier. In logistics, this retrieval process is called “picking.”

Order picking systems can be roughly classified into the following categories:

- Manual order picking
- Semiautomatic order picking
- Fully automatic order picking

A decisive criterion for the performance of a system is the efficient combination of the order picker and the article in order for him or her to perform the order picking process. From a systematic perspective, order picking consists of the following system functions:[7]

1. Movement of the goods for provision
2. Provision
3. Continued movement of the order picker to the point of provision
4. Retrieval of the goods by the order picker
5. Transport of the picked goods to the disposal point
6. Disposal of the picked goods
7. Transport of the order picking unit to the disposal point
8. Disposal of the order picking unit
9. (any return transport of the opened load unit (pallet, box))

The system functions can be designed along a spectrum from completely manual to fully automated. As mentioned above, mainly manual or semiautomatic order picking solutions are used in the mail order business since the range of articles is generally very heterogeneous and changes frequently and, due to manual order receipt fluctuations (e.g. Christmas business), manual systems can be implemented more flexibly.[8]

[5] Cf. ten Hompel, Schmidt and Nagel 2007
[6] Cf. ten Hompel, Schmidt and Nagel 2007 und VDI-3590 Page 1 1994
[7] Cf. ten Hompel, Schmidt and Nagel 2007
[8] Cf. Düsing 2010

Manual picking describes the deployment of personnel for performing picking tasks. Here, the worker is a main part of the process as he or she is responsible for the correct retrieval, order assembly, and provision of articles for one or more customer orders.

Using the example of the mail order business, the right article must be picked in the right quantity and the right (demanded) quality based on the picking orders before being consolidated and provided for further processing (packing, loading, transport). To support manual order picking, the worker must be provided with various aids to complete the task of order picking.

The following aids are usually used in order picking:

- Document (pick list)
- Mobile data entry device (MDE), paperless)
- Stationary terminals (paperless)
- Optical displays on shelves (Pick-by-Light, paperless)
- Voice-guided instructions (Pick-by-Voice, paperless)
- A mixture of methods for designing individual order picking systems
- Further (new) technologies (e.g. Pick-by-Vision, Pick-by-Watch, etc.)

Order picking via stationary terminal

Order picking via Pick-by-Light

Order picking via Pick-by-Vision

Order picking via Pick-by-Voice

Using workers and the available aids, errors can occur during and after order picking. These errors can have a negative effect on the company. Figure 1 shows an example of the average error rates in manual order picking.

Here, taking into account that the processing of up to 100,000 articles a day (retrieval quantity) in the mail order business is not an unusual situation, it can be concluded that the reduction and/or elimination of errors during order picking should be a decisive starting point for optimization for the respective company. Under consideration of the costs for eliminating errors – which amount to about EUR 25 according to a survey (company-internal elimination of errors) – the potential for preventing errors in manual order picking systems is made clear once again.[9] The following figure shows the error rates and costs in detail.

It must be noted that the precise error costs can only be approximated. All costs must be analyzed and evaluated. Nonetheless, this method is suitable as an approach for determining potential in manual order picking. For the "Articles per day", a moderate order handling of 5,000 order articles and a retrieval quantity of 1 piece per article was assumed. For the error costs, a moderate value of EUR 10 per error was assumed. If the error costs per day are extrapolated for the entire year, error costs within a range from EUR 9,600 to EUR 120,000 (at 20 workdays a month) result.

The approach clarifies the high potential that lies in error prevention in manual order picking systems and provides information about the areas on which the optimization of fields of action should concentrate.

Overview of typical error rates and costs

Aid	Ø Error rate	Ø Articles per day	Ø Error costs	Ø Error costs per day
Pick list	0.35 – 1.00 %	5,000	10.00	175.00 – 500.00
Mobile data entry device	0.46 %	5,000	10.00	230.00
Stationary terminal	0.94 %	5,000	10.00	470.00
Pick-by-Light	0.40 %	5,000	10.00	200.00
Pick-by-Voice	0.08 %	5,000	10.00	40.00

Figure 1, the author's own illustration based on Logemann 2007, ten Hopel, Schmidt and Nagel 2007 and Rammelmeier, Galka and Günthner 2012

[9] Cf. Logemann 2007 and Rammelmeier, Galka and Günthner 2012

A decisive factor for success in the reduction of order picking errors is the selection of a comprehensive approach. This approach is based on the consideration of the following fields of action: technology, organization, process and motivation.[10]

The measures for error reduction focus on these factors while representing the starting point of recommendations for action. In addition, the knowledge of the point of origin is an important criterion when selecting recommendations. Errors can be internal, e.g. arising during order picking or goods inspection, or external, e.g. arising directly on site with the customer. Recording the causes and effects of errors in a suitable, structured, and traceable manner is highly recommended.

> Intelligent, appropriate use of technologies such as pick-by-voice can reduce picking errors and increase productivity at the same time.

A possible methodological approach is the process and potential analysis for investigating company processes and the development of recommendations for action to improve conditions based on this analysis. The method is also suited in the area of analyzing errors in manual order picking systems since it guarantees a structured and solution-oriented implementation of measures for improvement (see Figure 2).

Figure 2: Process and potential analysis procedure (author's own illustration)

[10] Cf. Rammelmeier, Galka and Günthner 2012

The task of the process and potential analysis is the identification and evaluation of order picking errors. Through the evaluation of individual, identified potentials for optimization, they can be processed subsequently in a prioritized manner and implemented within the company. The objective of the procedure is to develop fields of action for the targeted reduction of errors with a comprehensive optimization approach. Additional subobjectives of the analysis and subsequent implementation projects are:

- Comprehensive consideration of the entire intralogistical spheres of function
- Neutral and practice-oriented procedures for implementation
- Establishment of the transfer of knowledge for the autonomous implementation of future optimization projects (interdepartmental)
- Derivation of optimization potentials that can be implemented in the short term
- Creation of a high acceptance among the employees under consideration and inclusion of their work activities.

Depending on the object of investigation, additional subobjectives can be added to the analysis and/or existing subobjectives can be replaced by new objectives.
The process and potential analysis is divided into the following three phases:

1. Recording of the actual situation and analysis
2. Identification and consolidation of optimization potentials
3. Evaluation and development of fields of action

Under consideration of the task of identifying the causes of errors and demonstrating their effects, the cause-and-effect diagram in particular is suitable as a planning aid. Depending on the target of examination, the selected planning aid can be further supplemented or replaced by a more suitable aid if required.

Based on the recording of the actual situation and analysis, optimization potentials and fields of action are identified and consolidated in the next step. In the last step of the analysis, a final evaluation of the feasible potentials and fields of action is performed and a result and measures documentation, which acts as a basis of implementation, is created.

Methodological framework of the process and potential analysis

– Pertinent planning aids and the result –

Contents	Planning aid	Result
1. Recording of the actual situation and analysis	■ Cause-and-effect diagram	■ Error structure
2. Consolidation of the optimization potentials	■ Brainstorming ■ Research ■ Knowledge and know-how	■ Optimization potentials ■ Fields of action
3. Evaluation and development of fields of action	■ Evaluation matrix ■ Value benefit analysis	■ Basis of implementation

Figure 3, author's own illustration

For a targeted examination and analysis of order picking errors, the definition of the project objective and the resulting requirements are a decisive criterion since the object of investigation must be precisely specified in order to work on the problem in a structured and focused manner and derive targeted measures. For the examination of errors in manual order picking, the target of consideration lies on the following types of errors in Figure 4:

Types of errors	
Error	**Description**
Quantity error	■ The picked quantity of the article is too high or too low.
Type error	■ An article was picked instead of or in addition to the correct article.
Condition error	■ The picked article is not in the right condition (e. g. incorrectly labeled).
Error of omission	■ An article was not picked (retrieval quantity of zero).

Figure 4, Types of errors (based on Rammelmeier, Galka and Günthner 2012)

There are numerous causes for the types of errors that can be viewed externally as main factors. The causes are generally summarized in the following main groups: human, method, technology, environment and other.

Such a classification supports the analysis process in regard to researching causes and making the effects of these errors visible. Based on the cause-and-effect ratio, targeted measures for the reduction and, ideally, elimination of order picking errors can then be developed.

In the initial phase, the causes and effects of existing order picking errors are recorded and analyzed. A possible method for the targeted revelation of order picking errors is the cause-and-effect diagram mentioned above.[11]

This analysis method guarantees a systematic and detailed determination of the causes and effects of processes, such as the development process of manual order picking errors. In regard to the order picking errors (e.g. errors of omission), the error is at the tip of the main arrow in the cause-and-effect diagram (see Figure 5).

The individual causes are then assigned to the main factors of influence as the cause of the error in the form of "branches." In an error analysis, the following main factors are essential components: human, method, technology, environment and other. The "human" criterion comprises all causes due to human properties. The "method" criterion takes all errors into consideration that result from the process design and any aids. Environmental conditions and the basic structure of the warehouse are assigned to the "environment" criterion, while the "technology" criterion includes the technical aids used in manual order picking. All other causes that cannot be assigned are included in the "other" criterion.[12]

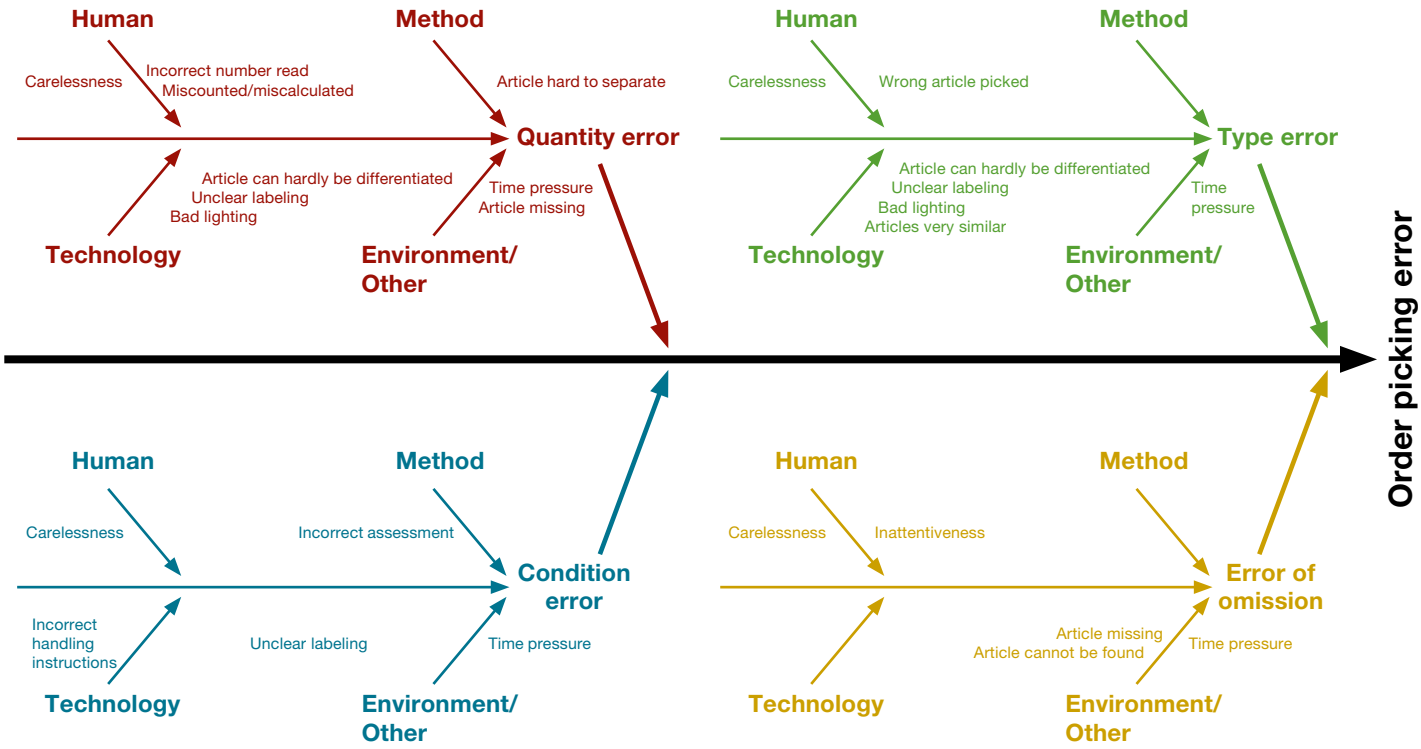


Figure 5: Cause-and-effect diagram (author's own illustration based on Rammelmeier, Galka and Günthner

[11] Cf. BMI 2005 and Rammelmeier, Galka and Günthner 2012
[12] Cf. BMI 2005 and Rammelmeier, Galka and Günthner 2012

In the second phase, the results of the recording of the actual situation and analysis are consolidated and summarized. In addition, measures for reducing order picking errors are identified and developed in this phase. The summarization and identification thus provide a comprehensive overview of the current actual situation and a possible target situation that can be achieved once the fields of action have been implemented.

Summary of the results	
Error/effect	**Cause**
Quantity error	■ Incorrect number read ■ Carelessness ■ Miscounted/miscalculated ■ Article is hard to separate ■ Article can hardly be differentiated ■ Article missing ■ Bad lighting ■ Unclear labeling ■ Time pressure
Type error	■ Article can hardly be differentiated ■ Articles very similar ■ Wrong article picked ■ Unclear labeling ■ Carelessness ■ Time pressure ■ Bad lighting
Condition error	■ Incorrect handling instructions ■ Carelessness ■ Incorrect assessment ■ Time pressure ■ Unclear labeling
Error of omission	■ Time pressure ■ Article missing ■ Carelessness ■ Inattentiveness ■ Article cannot be found (misplaced)

Figure 6: author's own illustration based on Rammelmeier, Galka and Günthner 2012

After the analysis of the causes and effect, possible fields of action can then be identified and developed. These fields of action act as measures for reducing and/or completely eliminating order picking errors.

Identification and development of fields of action		
Error/effect		**Fields of action**
Quantity error	*Causes*	■ Aid: Introduction and/or improvement of the technical aid for reducing the number of errors. ■ Monitoring: Increase in the monitoring instances (system-guided) using quantity and/or article checks, retrieval monitoring; final check of the order..
Type error		■ Storage location assignment: Similar articles are not stored next to each other. ■ Storage location assignment: Coded notification of the storage location (system-guided). ■ Monitoring: Means of checking the article number provided, e.g. system-guided with a reader.
Condition error		■ Instructions: Instructions and directions on how to handle the article. This can be implemented using technical aids in particular (e.g. information on mobile data entry devices).
Error of omission		■ Monitoring: Check of the retrieval quantity with the picking order, e.g. through technical solution. ■ Monitoring: Checking of the picking order for completeness, as well as article type and quantity.

Figure 7, author's own illustration

There are additional fields of action that are of significance for all types of errors. One field of action is to make employees aware and motivate them to prevent order picking errors. This can be implemented through regular training and instruction on the one hand and through incentives (monetary advantages and/or payment in kind) that should increase the motivation of the employees in the long term on the other.

In addition, establishing process and control circuits in which the employees also bear responsibility can contribute to reducing errors.

It must be noted that the measures for error prevention and the arising error prevention costs do not contradict order picking performance and error costs. If the order picking process is too strongly monitored, high error prevention costs arise in the form of cost per time unit and/or through the introduction of technical aids. These costs might not be higher than the error costs, because the company would ultimately have higher costs than those caused by the error itself. These factors must be taken into consideration in the development of recommendations for action and, particularly, in the implementation.

In the last phase, a final qualitative evaluation takes place to implement the fields of action and measures with the highest potential and benefit in a targeted manner (see Figure 8 Evaluation matrix (author's own illustration)). The evaluation takes the implementation potential (1), investment effort (2), implementation time (3) and expected error reduction (4) into consideration.

A suitable evaluation system is the allocation of scores to each field of action within the four categories. As shown in Figure 8, the field of action with the highest total point value has the highest benefit in regard to overall implementability. Within the scope of the process and potential analysis, the exemplary measures catalog is the foundation of the subsequent implementation projects.

The evaluation in Figure 8 shows that regular training and instruction (31 points) have the greatest potential for reducing errors in companies. Nevertheless, the introduction of technical aids in order picking, e.g. using mobile data entry devices (29 and 30 points), has a high potential in regard to error reduction. The evaluation also makes clear that the individual fields of action and the suggested measures have to be considered, combined and implemented in the overall context.

Evaluation of the fields of action and optimization potentials (exemplary)							
Error	Field of action	Suggested measure	Evaluation				
			Implementation potential	Investment effort	Implementation time	Error reduction	**Sum**
Quantity error	■ Aid: Introduction and/or improvement of the technical aid for reducing the number of errors. ■ Monitoring: Increase in the monitoring instances (system-guided) using quantity and/or article checks, retrieval monitoring; final check of the order.	■ Introduction of mobile data entry devices (MDE) as a technical support for manual order picking.	9	6	7	7	**29**
Type error	■ Storage location assignment: Similar articles are not stored next to each other. ■ Storage location assignment: Coded notification of the storage location (system-guided). ■ Monitoring: Means of checking the article number provided, e.g. system-guided with a reader.	■ New storage location assignment (manual or system-guided) and introduction of storage location codes. Further simplification and error reduction in combination with MDE.	9	7	5	6	**27**
Condition error	■ Instructions: Instructions and directions on how to handle the article. This can be implemented using technical aids in particular (e.g. information on mobile data entry devices).	■ Implementation of regular training and instruction, as well as making employees aware of how to handle order picking errors.	8	9	8	6	**31**
Errors of omission	■ Monitoring: Check of the retrieval quantity with the picking order, e.g. through technical solution. ■ Monitoring: Checking of the picking order for completeness, as well as article type and quantity.	■ Introduction of mobile data entry devices (MDE) as a technical support for manual order picking. In addition, the introduction of other technical aids is conceivable (cost-benefit analysis).	9	6	7	8	**30**

Figure 8: Evaluation matrix (author's own illustration)

Evaluation scheme:

Implementation potential	Investment effort	Implementation time	Error reduction
0 – 3: Very low	0 – 3: Very high	0 – 3: Very long	0 – 3: Very low
4 – 7: Good	4 – 7: Appropriate	4 – 7: Short	4 – 7: Medium
8 – 10: Very good	8 – 10: Very low	8 – 10: Very short	8 – 10: Very high

Based on the analysis of the causes and effects of errors in order picking and the subsequent identification and development of fields of action and optimization potentials, the qualitative evaluation and creation of the measures catalog formally completes the process and potential analysis.

At the end, a comprehensive result and measures documentation is available that forms the foundation for subsequent implementation projects. Figure 10 shows the basic structure of the measures catalog using the example of the introduction of mobile data entry devices in an overview. After a successful conclusion of the process and potential analysis and selection of the top potentials and fields of action, the individual measures are implemented, e.g. in the form of subprojects or an overall optimization project.

The implementation projects can be initiated and carried out with the following process:

Figure 9: Initiation of the implementation project (author's own illustration)

The fields of action can be selected using a weighted value benefit analysis, for example. At the same time, the company obtains a ranked list based on which each individual project can be implemented on the basis of the fields of action. As there are already many articles regarding the value benefit analysis in the scientific literature, the analysis is not described here any further.

Measures catalog (exemplary)

Error	Measure	Implementation (coarse description)
Quantity error Type error Condition error Error of omission	1. Implementation of regular training and instruction, as well as making employees aware of how to handle order picking errors. 2. Introduction of mobile data entry devices (MDE) as a technical support for manual order picking. 3. New storage location assignment (manual or system-guided) and introduction of storage location codes. Further simplification and error reduction in combination with MDE. Assumptions: ■ A warehouse management system for system-guided implementation exists. ■ Document-oriented order picking in actual state.	1. Formation of project team ■ Naming of project manager ■ Naming of project members ■ Project initiation 2. Selection of the measure (e.g. using a value benefit analysis) ■ Selection of measures (prioritized) ■ Scheduling and resource planning for the measures 3. Execution of implementation ■ Start of the implementation of the first measure ■ Implementation phase according to schedule ■ Completion of the implementation 4. Monitoring of success and stabilization after implementation ■ Check of the effectiveness of the measures (e.g. through measurements, observance of the regulations) ■ Readjustment and stabilization of the measures ■ Start of planning the next measure

Figure 10, author's own illustration

In the mail order business, most of the orders are processed using manual order picking systems. Among others, the reasons include strong seasonal fluctuations and a frequently changing article range. Automated order picking systems, for example, are frequently oversized or undersized, which in turn affects the economic efficiency.

Even if people are highly flexible and are deployed in order picking for a heterogeneous or frequently changing article range in particular, the low performance in comparison with automated systems and the making of order picking errors by people is disadvantageous for this kind of system. In addition to monetary losses, order picking errors can also have a non-negligible, negative influence on customer satisfaction and the company image.

> Implementation of such technologies is only successful when data is collected, measurements recorded and measures are derived to prevent errors.

Order picking errors can cause considerable damage to a company. Reducing errors or eliminating them completely is therefore a decisive factor for success. Nonetheless, any arising error prevention costs must be proportionate to the error prevention itself.

One possibility for the target analysis of causes and effects and the identification and development of fields of action for eliminating errors is the process and potential analysis. As a result of this analysis, fields of action for the reduction and/or complete elimination of order picking errors have been developed and then evaluated and listed in the form of a measures catalog in an exemplary manner. The cause-and-effect diagram is especially suitable as a planning aid within the analysis due to its easy comprehensibility and clear presentation.

The evaluation also makes clear that the individual fields of action have to be considered, combined and implemented in the overall context.

- **Investment in new picking technologies:**
  Investing in new or best-of-breed technologies, such as mobile data entry (MDE) devices and pick-by-voice, not only contributes to increased picking productivity, but reduces picking errors too. With proper planning, short payback periods are also possible and in some case they are less than 1 year.
- **Regular training sessions:**
  Training sessions help make sure that items are correctly picked from storage locations. Product training sessions give workers the skills to pick items in the right way, thereby helping to prevent damage.
- **Sensitization to the cost of errors:**
  Sensitization familiarizes employees with errors and the cost of errors, thereby creating the awareness needed to prevent errors. Awareness can be further improved by transferring direct responsibility for the quality of the picked items.
- **Creating an ergonomic work environment:**
  An ergonomic working environment helps reduce picking errors and increase acceptance of the workplace. Employees can only perform to the right level if they feel comfortable and well at all times.
- **Profit-sharing:**
  Profit-sharing or extra pay can also contribute to the success of picking by reducing picking errors and increasing picking quality even further. Profit-sharing can be designed e.g. on the basis of the performance of individual employees or groups of employees.

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