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# MEASURING THE MATURITY OF DIGITALIZATION TRANSFORMATION FROM OPERATIONAL EXCELLENCE'S PERSPECTIVE

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## Abstract

*Operational Excellence (OE) means the development of innovative sustainable production science and technologies that cover the entire live cycle of products but also of services. The food-packaging industry examined in this paper so far lacks a comprehensive yet consensual framework that encompasses all aspects of measuring the maturity of digitalization transformation from an Operational Excellence's perspective. Consequently, this paper aims to show the significance of the application of Industry 4.0 technologies in a lean environment - in the food-packaging sector. For OE initiatives, the main question is the inefficiencies that occur at different stages of production. A systematic literature analysis helps to identify existing maturity models in the context of the research fields of digitization, Industry 4.0 and in particular the process digitization. Based on this, a maturity model will be designed and evaluated in a company-related application context. With certain modifications, Industry 4.0 concepts and technologies can be applied to the observed case plants. Combining these advanced technologies with lean principles can lead to better OE initiatives than applying these concepts alone. The paper provides insight into the current state of knowledge in the respective areas and suggests the way forward for future research.*

**Keywords**

Maturity Model, Digitalisation, Operational Excellence, Food-Packaging

## 1. Introduction

It is of enormous importance for companies in the food-packaging industry to know both the structures of the market and the competition, as well as the forces and influencing 7 factors that affect them. A company in the food-packaging industry must have an idea of which factors affect the competition to formulate strategies and be successful. In terms of successfully establishing and asserting oneself in the market, it is of enormous importance to know both the position of one's own company and that of the competitors (Paulin & Suneson, 2012, Trautman, 2022). To do this, the company must know its strengths and weaknesses and those of its competitors. The same applies in this context to the opportunities and risks. Knowledge of the strategies of the market participants, possible changes in the strategy, or the reaction of the competitors to possible strategic changes of their own company or changes in the environment are also of enormous importance (Al-Qahtani & Aksoy, 2022). The dynamisation of the markets intensifies the competitive situation. In addition, the homogenisation of products and the ever-increasing variety of brands and products make it more difficult to differentiate oneself from the competition and to establish one's own brand. It is becoming increasingly difficult for companies to plan for the long term. Nevertheless, companies are striving to minimise uncertainties, dangers, and risks as well as to identify opportunities and competitive advantages. This is where Industry 4.0 comes in (Schuh et al., 2017). Industry 4.0 promises a new future that should bring a breath of fresh air to the company under study with innovative technologies, networking, and new business models. The Industry 4.0 maturity model contributes to the dissemination of Industry 4.0 and provides companies with a broader understanding and implementation proposals for Industry 4.0. (Aboelmaged, 2018, Malik & Kanwal, 2018). This paper aims to show the significance of Industry 4.0 of the case plant in the observed mass-production industry and the influence of Industry 4.0 on strategic decisions, especially on positioning decisions, and the extent to which this process is influenced by the development of external influences and framework conditions (Tuan, 2020, Ganguly et al., 2020). The term digitalisation is currently a very big buzzword that is used in many different ways and frequently in the industry. Digitalisation is a basic prerequisite for linking the real world with the virtual world of products or production processes in Industry 4.0. Without digitisation, the introduction and application of Industry 4.0 is not possible. Consequently, the importance of digitalisation will be examined in more detail. In the literature, the term

"digitalisation" is also not clearly defined and differs about the area of application and the user's perspective (Steven, 2019, Mertens et al., 2018).

### 1.1. The Environment of The Observed Food-Packaging Plant

The observed plants are medium-sized plants within the same group in the food-packaging industry. The one case plant out of the company group used for illustration is taken from the real context of the plant but formulated in such a way that it is not possible to conclude the company from the facts. It is not the intention here to reproduce the entire competitive analysis carried out earlier by the case company, which served to identify competitors. Only some basic characterisations of the competitive environment should be taken up. Against the background of increased cost-cutting, the focus of market cultivation has been increasingly extended to large companies since the 2000s. A stronger orientation towards the production of regularly updated standard products is also noticeable. In the area of strategy, the plant can claim certain unique selling points due to its elaborate, research-based production approach. Tough competitors here, however, are the plants directly linked with the plant and therefore not completely independent, which by their very nature can compete primarily on pricing. The observed case plant with a rather European orientation is thus predominantly confronted with competitors who are internationally or globally active.

## 2. Literature Research

The literature review includes a comparison of existing maturity models in the research area of digitalisation of business processes and thus provides the conceptual basis for their further development. In order to understand maturity models in the context of digitalisation, it is necessary to record how they were developed in previous research. The literature analysis aims to create the basis for the development of the new maturity model by identifying and documenting the central characteristics of existing maturity models in relation to the digitalisation of business processes. Before the identification and analysis of the existing maturity models can be carried out, the focus of the literature analysis is determined according to the characteristics defined by Cooper (1988) in order to achieve the goal. Accordingly, the focus is placed on the results and the methods applied. The goals are the integration of the results and the critique of existing models. A neutral presentation for application in science and practice is aimed. The literature analysis is realised completely selectively based on defined selection criteria; it is oriented towards the conceptual frame of reference of digitalisation. The literature screening phase involves identifying adequate literature for the defined research (Becker, 2012). Accordingly, those literature sources are to be

identified that refer to maturity models and are related to digital business process management, the digitalisation of companies or business models, or to Industry 4.0. Furthermore, process models and reference models for digitalisation as well as other publications on the topic of digital business processes are to be integrated into the synthesis in order to be able to identify relevant findings across models. To ensure objectivity and reproducibility in the research process, the predefined criteria for literature selection must be documented (Schuhmacher et al., 2016). The literature search is limited to the most important databases in business administration and information systems. The databases ProQuest, EBSCOhost, and Springer Link were selected. In addition, Google Scholar was used for the scientific literature search. Due to the high relevance for practice and the strong dynamics as well as topicality within the research field under consideration, a Google search is also conducted. This ensures that additional practice-oriented sources and information on trends are taken into account in the search.

## 3. Research Issues

Especially companies in the food packaging sector must deal with the far-reaching effects of digital transformation. Digital transformation not only presents these companies with the challenge of recognising the potential of new technologies and innovations, but they also have to adapt existing processes to the new technological status quo and always keep an eye on the adaptation of the existing business model to the new conditions (Berghaus & Back, 2016b). A prerequisite for successful transformation is that food packaging companies develop a strategy for digital transformation and that they are open to adapting their processes and products, as well as their organisational procedures (Yoo & Lyytinen, 2010). To overcome the complex challenges associated with digitalisation, company management must be aware of the developments and trends in the market, but also of the company environment, to develop a strategy for digital transformation based on this and to derive appropriate measures from this (Berghaus & Back, 2016a). A recent study by the Institute for SME Research (IfM) from 2017 shows that small enterprises are striving for strategic corporate management with a special focus on customer behaviour and the further development of the business model. However, the strategic orientation of the companies is often too vague, so they do not have a sufficient basis for a targeted and methodical approach to the introduction and implementation of new digital technologies and business models (Nielen, Kay & Schröder, 2017). Companies lack a tool that allows them to both assess the status of the digital transformation in their company and to record the necessary steps for implementing the digital transformation. Maturity models are a tool that helps to solve this

problem. They can help managers to systematically assess the organisation about the digital transformation and to identify development perspectives (Becker, Knackstedt & Pöppelbuß, 2009). Of particular interest to the author are not the classic maturity models, which mainly deal with the management of information and communication technologies, but specific maturity models for the digital transformation of food-packaging companies.

## 4. Methodological Analysis

The analysis is based on Mettler et al. (2010) and classifies the identified maturity models according to the criteria of architecture, application, origin, and reliability. The methodological analysis revealed that the majority of the maturity models originate from science. In approx. 89 % of the selected contributions, the models are textual descriptions and only a few cases are a questionnaire. In a few other cases a combination of a text description and a questionnaire has been identified. None of the maturity models has a formal architecture with comprehensively defined criteria for maturity assessment. Self-assessment is used for assessment purposes in the majority of the papers and only a few models use third-party assessment. These are primarily consulting firms that also use the models for new client acquisition. An indication of the low level of standardisation in this research field is that none of the identified maturity models serves as a basis for certification. Furthermore, the lack of evaluation of several models suggests that they are not sufficiently methodologically sound. Therefore, the need for an evaluated model with an evaluated development process becomes apparent.

## 5. Development of The Maturity Model

The goal in this context was to develop an analysis tool in the form of a maturity model for the topic "Measuring the maturity of digitalisation transformation from Operational Excellence's perspective". This topic refers to sustainable and modern production in the food-packaging industry. Thus, the focus here is on manufacturing companies that process intermediate products and produce end products (Becker et al., 2009, De Bruin, 2005).

### 5.1. The Need for A Maturity Model

At the beginning of the design of a maturity model, it must be assessed whether the maturity assessment and analysis can and should be applied as an appropriate control instrument. Particularly, if the intended development or change project has a large temporal extension or the characteristics of the development status are difficult to quantify due to the high complexity of the project, e.g., in research projects or continuous improvement processes in the sense of

organisational development, the use of maturity models makes sense. It should be noted that the determination of the maturity level requires the analysis and evaluation of existing processes practised by employees in order to increase the transparency of the object under consideration.

### 5.2. The Specification, Analyses of Existing Maturity Models

With the delimitation of the object of observation for the maturity model to be designed, it must be defined which structures and processes are to be part of the maturity assessment and which are not to be included in the observation. For this purpose, a simple structure diagram can be used, which captures and links the elements of the object under consideration and its relevant characteristics. Based on this, the objectives can be defined by selecting the characteristics of the object under consideration that are to be captured and quantified by the maturity model to be designed.

### 5.3. The Structure of The Maturity Model

Due to the large number of current maturity models, the first step was to observe the extent to which understanding can be gained from the known models for the design of digital transformation activities. In this context, the dimensions and maturity criteria in specific were analysed and evaluated in terms of their suitability for digital transformation. The basis for this was a systematic literature analysis of mainly English-language publications. As a result of the analysis, 88 models were identified that focus on the digital transformation or digitisation of companies. With regard to the dimensions found, the evaluation of the systematic literature analysis revealed a large degree of agreement in the publications. Thus, on the one hand, literature, the dimensions of strategy, culture, customer and governance, as well as employees and customer experience are mentioned most frequently. On the other, strategy is the most frequently mentioned dimension. The dimensions digitalisation and sustainability, as well as operational excellence and processes, are listed most frequently in order. According to the manual analysis, the dimension of technology only plays a subordinate role. Maturity can be captured qualitatively or quantitatively in a discretely or continuously manner (Kohlegger et al., 2009). Following the systematic literature analysis, the results in this paper were verified with the help of qualitative data analysis.

### 5.4. The Maturity Models

Maturity models are described in the literature as "describing a sequence of maturity levels for a class of objects thereby showing an anticipated, desired or typical development path of these objects in successive, discrete rank stages, starting at an initial stage and ending with complete maturity" (Becker et al., 2009). Maturity models are thus a suitable instrument for the systematic development as well as stepwise improvement of capabilities, processes, structures, or framework conditions of organisations. An important prerequisite is that the features and

characteristics of the individual development levels are clearly defined beforehand so that the user indicates what is necessary to reach the next maturity level. This is exactly why maturity models are a suitable instrument that enables management to recognise the necessary changes in the company and to approach the transformation process in a structured way (Schuhmacher et al., 2016). Maturity models have proven themselves as instruments for the management of information technologies, particularly in computer science and information science. They are therefore not a new set of tools. However, the existing models cannot simply be transferred to digital transformation, as they are only focused on one or a few company areas. This means they are not suitable for capturing the overall picture of a company. It follows that a specific model is needed for the systematic development of capabilities as well as for managing the digital transformation process (Becker et al., 2009).

### 5.5. The Levels of The Maturity Model

Each maturity indicator has five development levels. These are conceptually based on the Industry 4.0 readiness study (Lichtblau et al., 2015, Ritzrau, 2017).

**Level 1 Unsystematic Process:** The business process and systems are not standardised or are poorly documented. Process management is reactive and does not have the right organisational and technical concepts or tools for building a digital infrastructure that enables process agility. External digital expertise is used in the company because there is no internal expertise.

**Level 2 Defined Process:** The business process is partially digitised and standardised. Due to deficiencies in the organisation and/or the basic technologies, process management is weak. In individual departments or process steps, there is a discernible engagement with digital solutions and their introduction. However, there is little acceptance of the isolated solutions that have been developed.

**Level 3 Established Process:** Increasing competences in the company are developing more comprehensive solutions for process execution. However, there are still some constraints of organisational responsibilities and/or enabling technologies that limit the digital implementation of process management. Therefore, there are still deficiencies in the planning and execution of processes, as well as in the integration and interoperability between applications and in the exchange of information.

**Level 4 Controlled Process:** The processes are now designed endwise with a high degree of standardisation within the company. The processes rely on the integration and interconnection of systems and data so that they can run in an automated way. As the competencies of those involved in the processes increase, so does the acceptance of the digitised processes and the digital working

culture support the company in achieving its goals. The digitalisation of business processes is perceived as strategically important.

**Level 5 Optimised Process:** The business processes are comprehensively digitally oriented and based on resilient technology infrastructure and comprehensive integration of all systems and data. Both the exchange of information and the system landscape are highly standardised and secured by comprehensive security concepts across company boundaries. All data analyses are automated and flow autonomously into the process optimisation of the linked systems and machines. The high level of digital competence of all process participants is maintained through an optimal flow of information and explicit knowledge management.

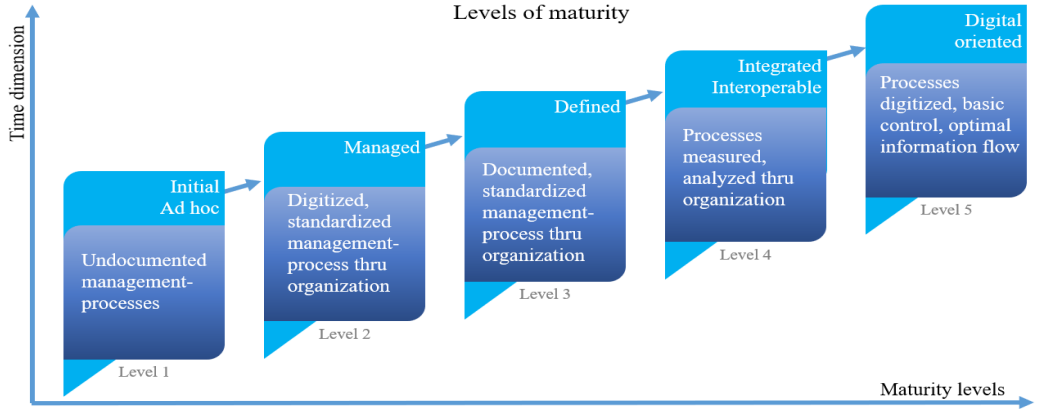


**Figure 1:** *Level Maturity Model*

*(Source: Own Construction of Author Based on Janse, 2018)*

### 5.6. The Maturity Model for Digital Transformation

Characteristics of the maturity model for digital transformation for the case plant is the dimensions with which the criteria of the transformation process are defined and characterised in more detail by further categories (see Figure 2). The following is a more detailed description of the dimensions. Specific questions are formulated for each category to assess and evaluate the individual specific questions are formulated for each category. In this context, five maturity levels were defined as development stages. A maturity level is determined for each category. Subsequently, an average value is formed, which results in the total value for the respective dimension. The average of the values of the dimensions results in the overall maturity level of the case company. The higher the value, the higher the maturity level achieved.

**Dimension 1 Change Mgmt.:** To assess the digital maturity of the business processes, it is also necessary to evaluate the extent to which the digital transformation is also implemented within the framework of the culture and among the people. Therefore, change management that promotes the measures for adapting to digital processes is to be expected. Employees in the company are

involved in digital transformation and have a central role in the change processes (Spath et al., 2013).

**Dimension 2 Data Mgmt.:** In a digital context, business processes are based on data and information that enable processes to be linked, automated, or executed autonomously. Therefore, data is essential for the optimal execution of processes. Accordingly, essential requirements must be placed on the data, which thus represent an important assessment basis for the digitalisation of business processes. The real-time use of data by business processes is also an indication of the extent of digitalisation, as the effective use of data is what makes the advantages of digital technologies possible in the first place. In the process, the flexibility of the entire company is increased through timely response options.

**Dimension 3 Digitalization Mgmt.:** This dimension assesses whether there is a digitisation strategy and whether the business processes are already compatible with the digitisation strategy. The strategy compatibility of the processes must be assessed, i.e., to what extent the objectives of the strategy can be supported with the execution of the processes. Digital management includes the elements that must be in place for the decision-making process to be carried out accurately, objectively, and efficiently. It assesses the extent to which management makes strategic decisions for process design and possible process technologies using process simulations and all available information. This in turn promotes the development of an information-based culture and appropriate management.

**Dimension 4 IT Integration Mgmt.:** The IT systems and their degree of integration into the business processes are essential for assessing the digital business process maturity. The horizontal integration across different IT systems is assessed so that the internal and especially also cross-company links of the individual process steps can be improved. The aim of integrating different IT systems at the same hierarchical level is to create value more efficiently. The aim is to achieve end-to-end automated value creation by directing all internal as well as cross-company resources. Vertical integration is also an important aspect of business process digitalisation. A large volume of collected data is created throughout the entire business process. In this context, vertical integration involves linking different IT systems across hierarchical levels so that the machine level and the planning level IT systems can exchange data with each other.

**Dimension 5 Lean Mgmt.:** To assess the digital maturity of the business processes, it is also necessary to evaluate the extent to which the digital transformation is also implemented within the framework of the culture and among the people. Therefore, lean management is to be expected, which promotes the measures for adapting to digital processes. Employees in the company carry the digital transformation with them and have a central role in the change processes (Spath et al.,

2013). To avoid frustration and excessive demands on employees and to increase the acceptance of the digitalised processes, those involved in the process should be involved at an early stage and their know-how should be taken into account for the design and procedure.

**Dimension 6 Process Mgmt.:** The assessment of digital process management records the extent to which digitisation has already been implemented and, accordingly, new measures are applied to optimise the processes. An additional goal in the context of digitalisation is that the process steps meet the requirements of all technologies and digitalisation tools so that these can be integrated into the processes in an agile and quick manner. A high level of transparency in the processes is essential for this. This is created by process descriptions according to the principles of proper modelling or by process mapping so that all processes are documented in detail. For better application and optimisation, the documentation must also be digitalised.

**Dimension 7 Quality Mgmt.:** In essence, it is not only about acceptance of digitalization, but also about the quality of the process as well as the results. In addition to timely involvement, the development of digital competencies of those involved in the process enables them to actively support the quality process for digitalisation. This involves adjustments to the required competencies and the extent to which companies can provide them. Therefore, when recruiting new employees, it is important to ensure that they have a digital affinity and that the existing quality stakeholders receive further training and are constantly informed about the current status. In addition, internal expertise on the topic of quality in digitalisation must be built up so that there is no dependence on external consultants.

**Dimension 8 Supply Chain Mgmt.:** Digital transformation is based on the development and transfer of knowledge within a company (Margherita & Petti, 2010). Therefore, supply change management must be considered to be able to promote both the digital culture and expertise. In addition, the alignment of business processes with an overarching digitalisation strategy is an essential factor in assessing digitalisation maturity. The organisational dimension also includes process management, which is subject to digital transformation. It is not helpful to digitise complex and wasteful supply chain processes, as this results in a poorly digitised process (Wiegand, 2018).

**Dimension 9 Sustainability Mgmt.:** Sustainability has been very present in all areas of business, politics, science, and the media for years. However, the term has undergone a change in meaning. In the past, it was first an everyday term and then a forestry term (Meffert et al., 2015). In contrast, sustainability is now used in many different contexts for environmental and climate protection, energy, innovation, and mobility, as well as for areas of development, design, education, and marketing (Tremblay, 2010; Marquardt, 2020). In connection with the change in meaning, the term "sustainability" is currently divided into the areas of social, ecological, and economic sustainability

(Akkasoglu, 2014). In the further course of the research, only ecological sustainability will be considered in studies and applications. This focuses on the responsible use and protection of natural resources. In addition, impacts on the environment should be reduced and biodiversity should be preserved (Cai, 2009, Deland, 2009).

## 6. Analysis

The evaluation of the results focuses on the 9 dimensions listed in the previous chapter 5.6, especially on the completeness of the dimensions, consistency of the values per dimension, and the usefulness of the maturity model. To substantiate the evaluation, 25 actors from the case plant were surveyed using an Excel-based self-assessment system, so that an initial evaluation is available in the field. This evaluation of the business processes for the individual maturity indicators at levels 1 to 5. By aggregating these evaluations, the maturity level can be determined at the level of the individual dimensions by taking the smallest level of the associated maturity indicators as the result. In this way, a pessimistic assessment of the maturity level is achieved in order to strive to ensure the digitisation of all areas in practice. If, on the other hand, the highest level of the maturity indicators was used for aggregation, isolated digitisation gaps could arise in the case plant. Subsequently, the median of the described dimensions is used to determine the maturity levels of the overall maturity level. Figure 2 illustrates this assessment for the evaluation case. The evaluation by interviewing the company stakeholders as users of the maturity model yields converging results regarding the evaluation criteria: (1) IT integration mgmt., (2) Process mgmt., (3) Quality mgmt., and (3) Sustainability mgmt.

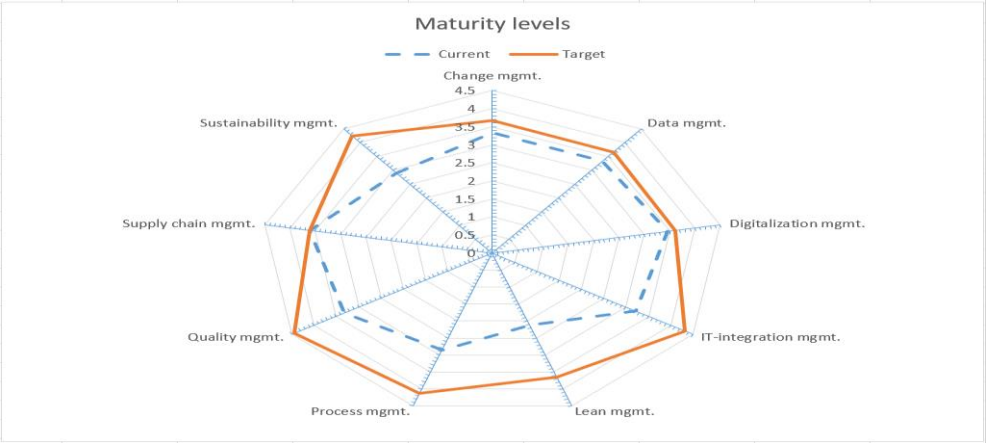


**Figure 2:** *Maturity Levels of Management Dimensions*

*(Source: Own Construction of Author)*

## 7. Conclusion

The presented Industry 4.0 maturity model supports companies in determining the actual maturity level and the target maturity level. The resulting improvement measures enable the company to develop toward the target maturity level in a strategy-led manner. The 9 dimensions are used to determine the maturity level. A comparison with other maturity assessments shows that the Industry 4.0 maturity model presented does not specialise in specific industries or application areas. The results achieved within the framework of this paper serve as a basis for evaluating the degree of implementation of the main topics in OE initiatives in the foot packaging industry.

### 7.1. Future Research

In this context, the maturity model developed is an important analytical tool to highlight the strengths and weaknesses of food-packaging plants. Nevertheless, more different companies need to participate in the validation of the maturity model to adapt possible maturity dimensions and indicators or to introduce additional indicators. Furthermore, industry-specific aspects should be included, which can change the weighting of the dimensions. Overall, the model presented here provides a methodologically sound reference framework for assessing the digital maturity of OE initiatives and can be further developed to meet the identified research needs. Another area of application for the process model is the integration of production and services, which is referred to as hybrid value creation. The assessment dimensions can take into account different areas of the integration of producers and service providers, starting with the corporate culture, through the integration of processes, to coordinated controlling systems. From the perspective of information systems, the maturity model could be used to examine, for example, the extent to which the actors involved exchange information to coordinate their performance contributions.

### 7.2. Research Limitations

The maturity model described is not a panacea and does not address all aspects that are important for successful projects (Brooks, 1987). The maturity model of Digital Business Processes is also not in a vacuum but embeds itself in the overall context of the food-packaging company or its projects. The success of projects for the digitalisation of business processes is therefore closely linked to a digitalisation strategy that is defined and communicated in advance. Furthermore, the support of the projects by managers is a basic prerequisite. A further limitation arises because the maturity model described does not currently deal with expertise in specific application areas, does not advocate specific software technologies, and does not make suggestions on how to select, recruit, motivate, and retain competent employees. Although these issues are critical to the success of a project, some of these issues have already been analysed in other

contexts (Curtis, 1990). However, they have not been integrated into the maturity model described. The maturity model described was developed specifically to provide an orderly, disciplined framework for addressing food-packaging management issues and the development processes required to address them.

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