Improving Production Ramp-Up Through Human Resource Methods

INA HEINE, PATRICK BEAUJEAN, AND ROBERT SCHMITT
RWTH AACHEN UNIVERSITY, AACHEN, GERMANY

This article provides an overview of selected human resource (HR) methods that have implications for the management of ramp-up phases. Based on the specific challenges within production ramp-up, the following six HR methods and corresponding instruments are outlined: knowledge management, competency modeling, reward systems, leadership development, employee selection, and team development. Each method is briefly described and suggestions within the context of ramp-up management are provided. This overview supports ramp-up managers' selection of HR methods that have the higher goal of improving ramp-up performance.

However, the practical implications of these HR methods are not clear, because empirical literature about the application of HR methods within the context of production ramp-up is limited. Further empirical research on the effects of specific HR methods on ramp-up performance, as well as detailed descriptions of the respective application and related expenses, are required to understand and evaluate their contribution.

Key words: competency modeling, employee selection, knowledge management, leadership development, managing ramp-up, organizational development, reward systems, team development

INTRODUCTION

This article deals with the research question of how to improve the stability of production ramp-up through the application of human resource (HR) methods. To answer this question, a framework of HR methods for ramp-up management was developed. The development of the framework is based on theory and well-known methods or concepts within the field of HR.

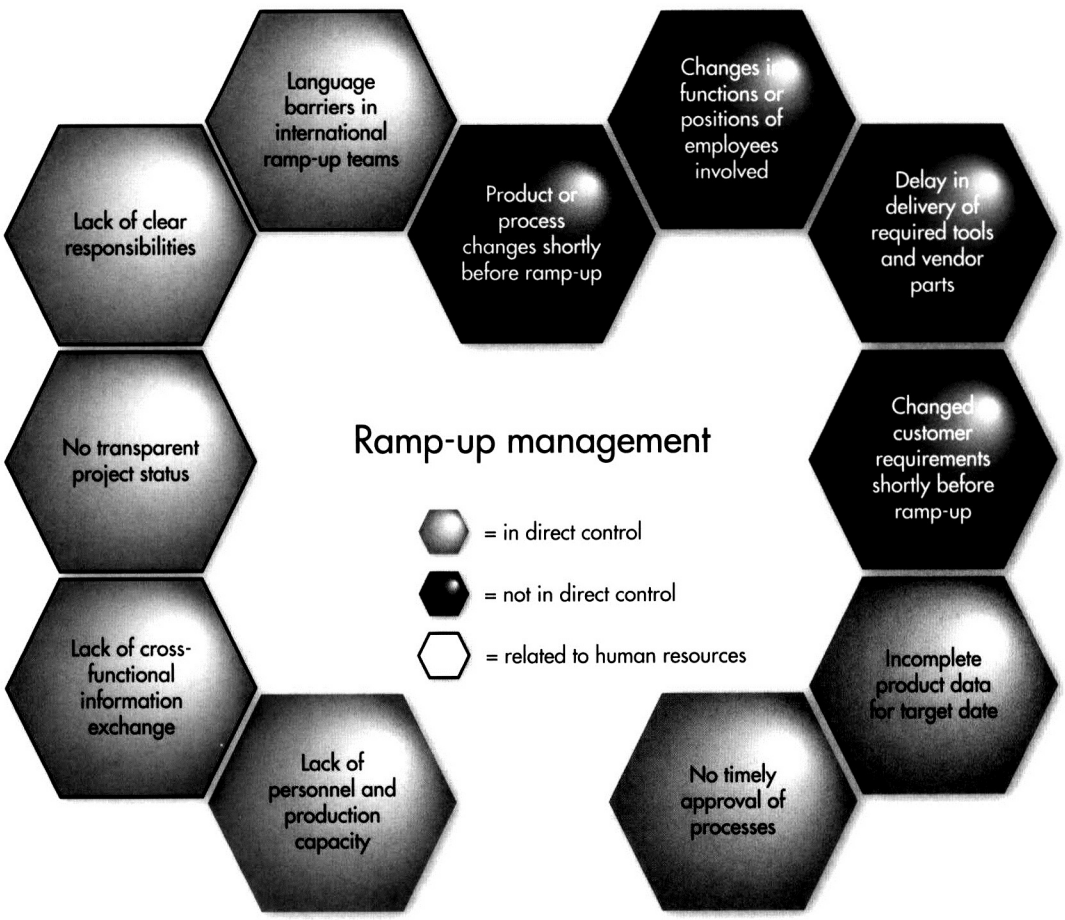
Ramp-up performance strongly determines a faster, better, and more cost-efficient serial production (Abele, Elzenheimer, and Rüstig 2003). Therefore, it contributes to important manufacturing performance measures that are relevant to production managers and quality management practitioners. For instance, improved ramp-up results in lower failure rates followed by a faster achievement of ridgelines and increased production stability on the requested output rate. Thus, the improvement of ramp-up performance in terms of stability is a precursor for better quality performance and, therefore, a grave indicator for a scalable production phase. However, performance improvements in production ramp-up are difficult to achieve because production ramp-up faces very particular and complex challenges due to unpredictable system behavior (Basse et al. 2014). Thus, enabling ramp-up teams to achieve their quality targets and to show good overall project performance is especially challenging for quality managers and requires approaches that go beyond the application of quality tools.

The main challenges within production ramp-up that negatively influence its performance are captured in Figure 1. In total, Herrmann, Wenda, and Bruns (2008) identified 11 challenges. These challenges are further classified into being under direct

control of the respective organization and not being under direct control and therefore difficult to influence. For example, if customer requirements change shortly before the start of production, this could have been anticipated, but it is not in the direct field of influence within the organization and is therefore difficult to change. When focusing on the challenges that are under direct control, four out of seven are related to HR. These are language barriers in international ramp-up teams, a lack of clear responsibilities, project transparency, and a lack of cross-functional information exchange. Thus, it appears that the majority of challenges during production ramp-up that are under direct control can be addressed by HR methods, which is one of the four fields of action proposed by Bruns (2010).

Based on the work of Bruns (2010) and the findings of a focus group meeting, a framework of HR methods for ramp-up management has been developed. Thus, the framework covers a selection of established methods that have been identified as promising means and should therefore be integrated into an organization's quality management practices. The framework provides quality managers with methods for improving quality-related outcomes that are less technical and more human centered. It is believed that these methods provide promising means for quality managers to enable project teams in increasing ramp-up stability and thereby improving quality-related performance in subsequent stages of the product life cycle. And although modern quality systems theory increasingly acknowledges the importance of "soft" facets in managing

Figure 1 Challenges during production ramp-up based on Hermann, Wenda, and Bruns (2008).



quality, they remain rather abstract and absent in practice. Thus, there is a need for further emphasizing these "soft" aspects within the field of quality management (Dahlgaard-Park et al. 2013).

The following section is a review of selected literature that covers ramp-up management and its phases. Next, the method through which the proposed framework of HR methods for ramp-up management was developed is outlined. The following section provides a general description of these HR methods and deduces hypotheses for further research. The article ends with a discussion of the results and further implications for research and practice.

RAMP-UP MANAGEMENT

Definition of Ramp-Up Management

As part of the product life cycle, ramp-up management embraces the process from the first physical prototype to mass production (Terwiesch, Bohn, and Chea 2001). While including the coordination of all start-up activities that are necessary to meet the logistic requirements for smooth manufacturing, the speed of ramp-up strongly impacts the time-to-volume of a product and by that its financial success through the reduction of opportunity costs (Haller 2003).

Although experts agree that manufacturing new products is marked by an increasing productivity rate (Terwiesch, Bohn, and Chea 2001), there is no general and widely accepted definition of ramp-up management found in the literature. Various authors refer to a variety of definitions; for example:

- "Ramp-up thus occurs as the last stage of development: the designs of the product and of the process are complete; prototypes have been made and tested; and now the transition is made to production in real conditions. The goods produced in this phase are intended for sale; goals for yields and quality thus play a major role" (Lenfle and Midler 2009, 5).
- Ramp-up is the "initial period of commercial production [...] it begins at start of production and finishes when initial targets for, e.g. quality, volume, yield, and costs are reached" (Fjällström et al. 2009, 179).
- "Production ramp-up is the period of time during which a manufacturing process is scaled up from a small laboratory-like environment to high-volume production. During this scale-up, the firm needs to overcome the numerous discrepancies between how the process is specified to operate as written in the process recipe and how it actually is operated at large volume" (Terwiesch and Xu 2004, 70).

The definition this paper relates to is provided by Koren et al. (1999, 537) as "the time interval it takes a newly introduced or just reconfigured production system to reach sustainable, long-term levels of production, in terms of throughput and part quality, considering the impact of equipment and labor on productivity" covering all important characteristics of ramp-up management, its influences, and typical procedure.

Phases of Ramp-Up Management

In general, the process of ramp-up management is divided into three phases: prototyping, pilot run, and start of production (Risse 2003a). To gain better insight into this process and to understand its challenges, an additional preceding development phase is added (Bruns 2010). The phases are outlined and analyzed in the following paragraphs.

Development In the first phase, ramp-up management is obliged to develop a strategy for the whole ramp-up process. To succeed in this phase, the relationship between ramp-up management and the preceding department of product planning, which has a huge impact on the time-to-market and time-to-volume, becomes very important (Schmitt and Schmitt 2011). Developers have the opportunity to share knowledge about future product attributes with the ramp-up management while they contribute relevant product requirements for manufacturing to the developers (Bruns 2010).

A common problem during this phase is the presence of misunderstandings concerning product characteristics that are relevant for manufacturing and meeting

customer requirements (Fitzek 2006). These are mostly based on insufficient information exchange. In order to correct these deficiencies, short-term changes of the product and the manufacturing processes become necessary. Without the specific knowledge about product attributes and whether the product is a new construction or the variation of an existing product that usually needs fewer resources, ramp-up management is challenged to provide a smooth production, and a short time-to-market and time-to-volume (Bruns 2010; Terwiesch, Bohn, and Chea 2001; Haller 2003).

In addition, a dysfunctional information exchange troubles the task to minimize costs. The better ramp-up management is integrated into the development process, the bigger is the advance concerning the reduction of costs. Cost-efficient decisions are only possible if the decider has detailed information about the development and construction of a product, as well as knowledge of the existing ways of manufacturing (Specht, Stefanska, and Gruß 2008). In conclusion, a close collaboration between product development and ramp-up management is required to optimize production ramp-up.

Prototyping Prototypes are used to implement the goals that were set during construction and product development. They already have the characteristics of the final product (Srinivasan, Lovejoy, and Beach 1997) and help to examine the aspiration. For ramp-up management, prototypes that are produced during and after the elaboration phase have an essential impact. Although expenses for prototypes cause a rise in costs, they are indispensable in offering the possibility to validate manufacturing capability (Bruns 2010).

Revealed problems and insights during the production of prototypes help to configure the future manufacturing mechanisms. Ramp-up management resides with the coordination of these acknowledgements toward construction and product development. This feedback helps to minimize quality issues and fastens the way to a marketable product that is suitable for mass production. Compliance of the prototype with a serial product is the goal of this phase (Drezner and Huang 2009).

Pilot run Pilot runs submit first reliable predicates about future production results and their reproducibility (Fitzek 2006). Before pilot runs start, a suitable production system must be developed. The complexity of this system depends on the characteristics of the new product. Depending on whether the product is a new construction or a variation, ramp-up management has to change an existing production or build up a new one (Bruns 2010).

Either way, employees are not familiar with and qualified to operate the new or updated production system. This could result in accidents, delays, and quality issues. Ramp-up management faces the challenge of integrating production employees into new processes and changes before the first pilot run. This creates acceptance and acquaintance with the new production system (Fitzek 2006).

The actual pilot run phase is divided into two subphases: pre-production batch and initial batch. The pre-production batch is an approach toward mass production but does not reach its productivity rate. The qualification and fineness of the production system are examined (Wheelwright and Clark 1992), and ramp-up management recognizes problems with production mechanisms and suppliers. The elimination of revealed problems is the greater goal of this batch.

After finishing all preparations for the production process, the first initial batch is supposed to start. The production system, tools, and suppliers have to be integrated into an overall concept (Bruns 2010). Unlike the pre-production, the initial batch has to run under mass production conditions to uncover additional problems that occur. Tani and Wangenheim (1998) revealed in their study that most weak points of the production system are discovered during the pilot run and emphasize the importance of this phase for ramp-up management.

Start-up The start-up phase directly follows on the initial batch. Its beginning is characterized by manufacturing the first suitable product for the customer (Schmitt and Schmitt 2013). This significant occurrence is also known as "start of production" (SoP) (Schuh, Stölzle, and Straube 2008). Ramp-up management is dedicated to evaluating the results of the initial batch and approving the SoP. By increasing the productivity rate, the start-up phase results in the superior goal of achieving a stable mass production (Laick 2003).

Stable mass production demands the completion of two criteria: quality criterion (low failure rate and so

on) and time criterion (cycle time) (Dombrowski and Hanke 2011). In comparison to a stable mass production, disturbances in production and logistic processes occur more often during the start-up phase. This causes a loss in quality as well as output and results in a higher input of employees and material (Held 2009).

Ramp-up management is responsible for the start-up phase and by that is obliged to eliminate these problems. With the adjustment and coordination of necessary improvements between development and production, failures in all areas are resolved one by one (Bruns 2010). Operating figures help to monitor this process. After a stable mass production is achieved, ramp-up time is finished and followed by serial production.

Ramp-Up Organization

In order to successfully manage all four phases, ramp-up management is most commonly organized as a project matrix organization. Organizations use this interdisciplinary approach because of the increasing complexity of production processes (Bischoff 2007; Schuh, Stölzle, and Straube 2008). But according to Schuh, Stölzle, and Straube (2008), companies that use this concept still have trouble providing the right amount of HR because flexible employee allocation often leads to resource conflicts between ramp-up and the product-line sector.

The foundation of a project matrix organization consists of a functional organized primary organization, which is overlaid by a project organization (Haas, Hermenau, and Romberg 2005). Due to the functional organization of the permanent primary organization, communication and alignment problems emerge that result in inefficiency between the functional areas (Risse 2003b). These problems are only partly reduced by the overlaying project organization, which usually involves a ramp-up manager and a ramp-up team to coordinate the product introduction (Bruns 2010). Because of the large number of interfaces, problems regarding affiliation and responsibilities emerge.

Besides these formal and areal structures, temporal and logical procedures have a huge impact on ramp-up management. Wheelwright and Clark (1992) point out that there are four different approaches to organizing these two procedures: 1) ramp-up teams with flexible employee assignment; 2) ramp-up teams with concrete employee assignment; 3) a distinct functional unit for execution of selected core tasks; and 4) a distinct functional unit for methodical support of all ramp-up activities.

Thus, in summary, it can be stated that ramp-up performance determines the stability of serial production and that ramp-up performance strongly depends on the collaboration between employees and other stakeholders. Figure 2 shows these hypothesized relationships as well as the six HR methods that were identified by a focus group to positively affect ramp-up performance. The next section gives a brief overview of the methodological approach that was adopted to develop the framework. After that, the proposed framework and its HR-related concepts as well as the deduced hypotheses, are outlined.

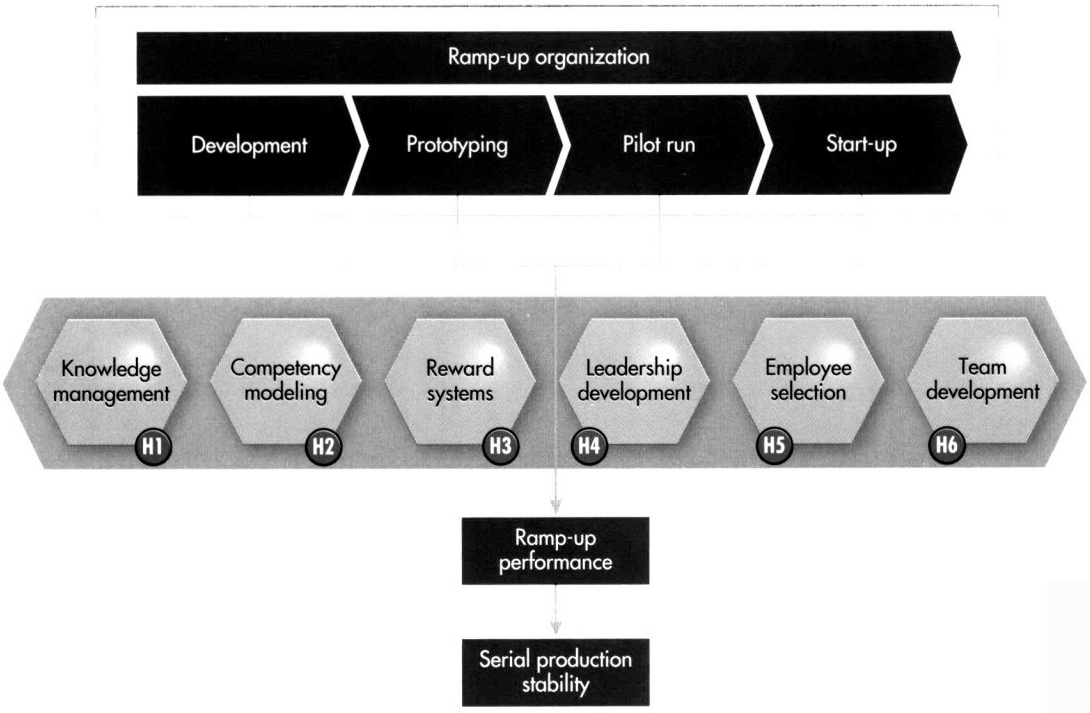
METHOD

In order to develop a framework of HR methods within production ramp-up, a focus group was established. The focus group consisted of five professionals with an academic background in industrial engineering and organizational psychology who met to discuss the research question of this article: "How do we improve the stability of production ramp-up through the application of human resource (HR) methods?" First, the meeting was introduced by presenting the four phases of ramp-up management and the identified challenges that were described previously. Based on this, the participants discussed HR-related methods and instruments for addressing these challenges. The findings of the focus group were clustered into six primary HR methods, which are described in the following sections.

FRAMEWORK OF HR METHODS WITHIN PRODUCTION RAMP-UP

HR methods have their origins in the discipline of human resource management (HRM), which is defined as the "effective utilization of employees to best achieve the goals and strategies of the organization, as well as the goals and needs of employees" (DeSimone and Werner 2012, 8). Bruns (2010) proposes four HR methods that can be applied to improve ramp-up performance:

Figure 2 Framework of HR methods within production ramp-up.



knowledge management, lessons learned, employee qualification, and reward systems. The relevance of these methods was confirmed in the focus group meeting. However, the method employee qualification was exchanged by the focus group for competency modeling because qualification is usually associated with formal education, while competencies can be also acquired on the job (Ellström 1997). Additionally, HR methods leadership development, employee selection, and team development were identified within the current study as relevant for improving ramp-up performance. The methods knowledge management and lessons learned were consolidated because lessons learned can be understood as an instrument for managing knowledge (Frey-Luxemburger 2014). In total, six HR methods were identified within the focus group meeting as promising for the improvement of ramp-up performance. In the following paragraphs the methods are briefly described and then applied to the context of ramp-up management.

Knowledge Management

Knowledge management is a "process of capturing and codifying knowledge for management (for example, profitable) purposes. It is often associated with information systems that store 'knowledge' in databases, but has become associated with the broader activity where management seek to appropriate the tacit as well as the explicit knowledge of their employees" (Sturdy 2012, 198). Thus, there are at least two challenges within the ramp-up that can be addressed by this method: the continuous flow of information and the conversion of implicit into explicit knowledge (Bruns 2010). Inside the field of knowledge management, different instruments can be applied. For example, to strengthen the storage and conservation of knowledge, an open items list (OIL) can be introduced by ramp-up managers. OIL is an instrument for project documentation that provides project teams with an overview of open tasks and responsibilities (Bruns 2010). However, OIL from previous projects can also function as a knowledge carrier that includes important implications for future projects.

Thus, in the context of ramp-up management it is useful to have an OIL for the current project to increase transparency. Bruns (2010) proposes including "milestones," "resources," and "barriers" as additional

categories that can be analyzed to identify important fields of action. Additionally, the authors recommend studying previous OIL of similar projects to avoid the repetition of mistakes. Another instrument for learning from past experiences and transferring knowledge is to carry out a lessons-learned workshop with the key players of a project (Gerhards and Trauner 2010). That means shortly before the parting point of ramp-up teams, a workshop with the aim to reflect about positive and negative incidents during the ramp-up phase should take place (Bruns 2010). The results of the workshop are recorded and shared with other ramp-up teams and serve as important input for future ramp-up projects (Schmitt and Schmitt 2013; Fitzek 2006).

Another knowledge management instrument that supports addressing the aforementioned challenges is the implementation of communities of practice (CoP), which "refer[s] to groups of people who interact (through meeting personally or electronically) and in doing so share knowledge and learn from each other through interaction" (Sturdy 2012, 199). CoP are considered to go beyond the sharing of explicit knowledge but to support the transfer and exchange of tacit knowledge (Shipton and Zhou 2008; Bartol and Srivastava 2002). Since ramp-up success is highly dependent on previous phases of the product life cycle, it would be useful to not only foster knowledge sharing between different ramp-up projects but to also include representatives of those phases. However, an important attribute of CoP is their informality (Cox 2005). Thus, organizations can offer the structures for those informal meetings by leaving free room for this purpose and by actively facilitating the participation but they cannot be obligatory. Overall, this leads to the following hypothesis:

- *H1: Ramp-up projects in which knowledge management instruments are applied lead to better ramp-up performance than projects in which no knowledge management instruments are applied.*

Competency Modeling

Competencies are "sets of behaviors, usually learned through experience, that are instrumental in the accomplishment of desired organizational results or outcomes" (Landy and Conte 2010, 118). More specifically, they are composed of knowledge, skills, abilities, and other personality characteristics (KSAOs) such as motives, traits, values, and so on (Clardy 2008). Competencies are considered better estimators for performance because of their direct relation to behaviors (Lucia and Lepsinger 1999). Thus, assessing competencies is a very useful way to estimate the fit between a candidate's profile and a job profile (Heinsman et al. 2007; Kormanik, Lehner, and Winnick 2009; Lee 2009). Competency models can be used for both personnel selection and development. The systematic approach consists of identifying the target profiles of employees, assessing their current profile, and deducing interventions to close the gap between the current and desired competency profiles (Lucia and Lepsinger 1999).

In general, competencies can be categorized as functional and cross-functional. Cross-functional or generic competencies are, like the name implies, general and widely applicable. They are independent of the profession and are not easily acquirable. In comparison, functional competencies are more specific. They describe the mastering of using specific software or other techniques that are more strongly related to specific jobs. Functional competencies can be further subdivided into methodological and technical competencies, while cross-functional competencies cover social and personal competencies (Gnahs 2010).

In the context of ramp-up management, different competency profiles for ramp-up managers and ramp-up teams need to be generated, although it is reasonable to assume that there might be some overlap between the required competencies. For example, both need a high degree of interactional (social) competencies such as teamwork (Bruns 2010) and conflict-solving abilities. These might be especially important considering the interdisciplinarity and therefore conflict potential in ramp-up projects. Another important group of employees that affects the performance of ramp-up phases is production workers. Usually, the total number of production workers is increased in order to cope with the upcoming instabilities during ramp-up by 7 to 15 percent (Bruns 2010). Thus, to improve ramp-up performance, required employee competencies need to be identified by analyzing high-performing ramp-up teams. Next, the actual

competency level of the respective employees needs to be assessed. Then, gaps between desired and existing competency levels become apparent. These gaps serve as a starting point for the systematic development of employees (Lucia and Lepsinger 1999). This leads to the following hypothesis:

- *H2: Ramp-up teams that consist of members whose competencies have been assessed and developed according to organization-specific competency models show better ramp-up performance than teams without specific competency modeling.*

Reward Systems

The next HR method leads to performance improvements through rewards. "Reward systems are multifaceted, comprising both financial and non-financial elements." (Davis and Scully 2008, 116). They serve as important instruments in shaping the organizational behavior on the individual and group level by increasing extrinsic and intrinsic motivation. Nonfinancial elements can range from job design over flexible working hours to attendance at courses or conferences (Mullins 2010). However, reward systems can only work and be perceived as fair if there is high transparency and consistency within these systems (Davis and Scully 2008; Bartol and Srivastava 2002). Rewards can be offered on both the individual and the team level. If rewards are allocated on the team level, members focus more on team than individual goals. However, team-based rewards include the risk of social loafing (Karau and Williams 1993). The performance can be either evaluated by a supervisor or through 360-degree feedback reflecting multiple perspectives (Day 2000).

In the context of ramp-up management, reward systems can be applied to strengthen knowledge sharing. Bartol and Srivastava (2002, 65) define knowledge "to include information, ideas, and expertise relevant for tasks performed by individuals, teams, work units, and the organization as a whole" and expect that knowledge sharing among employees increases if they perceive a personal benefit. If more knowledge is shared between different ramp-up teams, as well as across teams involved in previous and later phases of the production cycle, errors during ramp-up phases can be prevented. Because of the multiple stakeholders and team structure, the authors recommend providing rewards on the group level and using 360-degree performance appraisals as an evaluation method. Bruns (2010) recommends providing financial rewards for ramp-up managers who achieve important predefined milestones. However, the authors advise being careful with connecting rewards to targeted quality or costs because of the associated risk of covering up errors or other related problems. Overall, this leads to the following hypothesis:

- *H3: Ramp-up teams with team-based rewards for knowledge sharing within and across teams show better project performance than ramp-up teams without a reward system.*

Leadership Development

Day (2000) differentiates between leader and leadership development by emphasizing that the latter involves the development of interpersonal competencies while the other is directed at developing intrapersonal competencies. Thus, "leadership development can be thought of as an integration strategy by helping people understand how to relate to others, coordinate their efforts, build commitments, and develop extended social networks by applying self-understanding to social and organizational imperatives" (Day 2000, 586). Leadership development can be based on various instruments and practices, which might be either formal or informal. A selected summary is provided by Day (2000), including 360-degree feedback, coaching, mentoring, networks, job assignments, and action learning.

In the context of ramp-up management, mentoring and networks in particular seem to be promising approaches for improving performance. Mentoring practices usually involve a more experienced senior manager who has an advising role in the relationship with a less-experienced manager (Mullins 2010). Considering the importance of tacit knowledge in ramp-up management, it can be recommended to establish formal mentoring programs in which less experienced ramp-up managers can profit from the experiences of their mentors. Additionally, networks are useful for an increased cross-functional exchange of knowledge, which is an important prerequisite for

the successful management of ramp-up phases and the avoidance of errors due to missing information. This leads to the following hypothesis:

- *H4: The ramp-up projects of managers who receive formal or informal leadership development show better performance results than ramp-up projects of managers without leadership development.*

Employee Selection

The selection of employees can be based on multiple levels of fit depending on which level of analysis is considered. In organizational behavior, these are the individual, team, and organizational level (Robbins 1996; Mullins 2010). Thus, during the selection process, the fits between person-job, person-team, and person-organization can be assessed (Anderson et al. 2004). The following paragraph addresses the selection of employees on the individual level because the authors assume this to contribute most significantly to the improvement of the ramp-up phases, as it addresses the individual competencies of employees. Nevertheless, achieving a fit on all three levels is recommended.

The overall goal of employee selection is the prediction of individual job performance. The foundation for employee selection is the identification of which KSAOs or competencies are required to show high job performance (Salgado, Viswesvaran, and Ones 2001). The criterion job performance depends on the specific job (for example, ramp-up manager) and must be defined and operationalized. The most valid predictors for overall job performance have been general mental ability (GMA) and conscientiousness (Anderson et al. 2004). GMA refers to the general factor that accounts for most of the variance in ability measures, and conscientiousness is a personality factor that is associated with traits like "carefulness, thoroughness, responsibility, organization, efficiency, planfulness, and volition—hard work, achievement-orientation and perseverance" (Salgado, Viswesvaran, and Ones 2001, 173). To select employees according to specific individual characteristics, different selection methods can be applied. These include, for example, questionnaires, interviews, and assessment centers, which are based on a combination of various selection methods. For a more complete overview of the different personnel measures, including their validities, the reader is referred to Schmidt and Hunter (1998).

In the context of ramp-up management, ramp-up managers, as well as team members and production workers, could undergo a specific selection process. However, selection procedures are often only applied on a managerial level because they are associated with high costs (Salgado, Viswesvaran, and Ones 2001). Therefore, the authors recommend starting with a focus on ramp-up managers when developing and implementing a selection strategy. Conscientiousness might be an important predictor for the performance of ramp-up managers, as it is associated with traits that might be important determinants for achieving superior performance in ramp-up phases. Nevertheless, the exact requirements need to be identified through job analysis or similar methods before predictors and selection methods can be specified. Overall, this leads to the following hypothesis:

- *H5: The ramp-up projects of managers who have been systematically selected for the project show better performance results than ramp-up projects of managers who have not been systematically selected.*

Team Development

The effectiveness of team performance depends on the successful accomplishment of different developmental stages. According to Tuckman and Jensen (1977), teams undergo the following five stages: forming, storming, norming, performing, and adjourning. During the first stage the team forms and starts establishing relationships. In the next two stages, the team undergoes interpersonal conflicts, which are then resolved by establishing roles and shared norms. During the fourth stage, the team is oriented toward solving the problem and fulfilling the task. In the last stage, the team separates and each member continues working on new tasks.

In the work environment, the model is used to improve work performance and interpersonal processes (Bonebright 2010). Thus, in production ramp-up it can be applied to improve ramp-up performance. For example, ramp-up managers can organize team-building events to accelerate the forming stage, thereby

providing a good foundation for the storming and norming stage. A positive relationship between the team members is beneficial for the effective handling of conflicts, and thus the important stage of performing might start earlier. Since time is an important performance indicator for ramp-up, passing quickly through the first three stages should have a positive effect on ramp-up performance. In the last stage, it is important that the ramp-up manager organizes a lessons-learned workshop before the team officially separates. This separation can be initiated through a final team event for celebrating the successful accomplishment of a task. Another approach could consist of trying to create some stability within the team composition and thus avoid repetitive forming, storming, and norming phases within the team development process. The following hypothesis has been derived:

- *H6: Ramp-up teams that have worked together on previous projects show better performance in ramp-up projects than ramp-up teams that have not worked together on previous projects.*

DISCUSSION

The performance results of ramp-up phases have important implications for a successful and timely serial production. However, various challenges might impede the achievement of desired results. These challenges range from changed customer requirements shortly before ramp-up to a lack of clear responsibilities in organizational settings. While some of these challenges are not under direct control of the organization and are therefore difficult to change, a majority of the challenges can be directly addressed. Bruns (2010) proposes four fields of action: ramp-up organization, human resources, ramp-up controlling, and production technology. The focus of this article is on methods within the field of HR. HR methods have their origin in the discipline of HRM and have the aim to increase organizational effectiveness by managing personnel. In total, six HR methods for improving ramp-up performance were identified by a focus group and integrated into a framework of HR methods within ramp-up. These are knowledge management, competency modeling, reward systems, leadership development, employee selection, and team development. For each method selected, instruments were briefly described and applied to the context of ramp-up management (see Table 1). The instruments include open item lists, lessons learned workshops, communities of practice, competency gap analysis, individual and team-based rewards, mentoring, networks, individual-job fit, and team building.

The proposed framework of HR methods within ramp-up is supposed to enable quality management

Table 1 Overview of selected HR methods for improving ramp-up performance.

Method	Description	Instruments	Addressed challenges*
Knowledge management	Capturing and codifying knowledge for management purposes	• Open item list (OIL) • Lessons-learned workshop • Communities of practice	• Lack of information exchange • Project transparency
Competency modeling	Determining and developing competencies for increasing job performance	• Competency gap analysis	• Language barriers
Reward systems	Assigning financial or nonfinancial rewards for meeting specific goals	• Individual rewards • Team-based rewards	• Lack of information exchange
Leadership development	Developing interpersonal rather than intrapersonal competencies	• Mentoring • Networks	• Lack of clear responsibilities
Employee selection	Applying selection procedures to increase job performance	• Individual-job fit • Individual-team fit • Individual-organization fit	• Language barriers • Lack of information exchange
Team development	Improving team performance through considering developmental stages	• Team building	• Lack of clear responsibilities

*Depends on the specific application of the respective method (for example, selection criteria for employee selection).

practitioners to support ramp-up teams by applying techniques that go beyond classical quality tools. In this context the sensitization to closer collaboration between the different specialized units (that is, QM and HR) is also important. The expected result of applying the proposed framework is project teams meeting their ramp-up targets more probably. An anticipated long-term effect of better ramp-up performance is increased serial production stability. In practice, quality managers could formally implement some of the proposed methods into the process of initiating ramp-up projects. For instance, one possibility would be that ramp-up projects are only allowed to be managed by project managers who have proved to possess the required competencies. Another possibility would be that every ramp-up project has to start off with an action that fosters team building, which positively influences collaboration, an important requirement for good ramp-up performance. Furthermore, quality management practitioners should include knowledge management instruments like an OIL into the mandatory project management methods because it provides them with data for further quality analyses and decision making. Data-based decision making is at the core of quality management (Heine, Schmitt, and Beaujean 2015). However, for the moment the practical relevance of the framework is limited because the application of the proposed methods and instruments need further elaboration (for example, identification of required competencies). Additionally, a comprehensive framework for improving ramp-up performance should include further fields of action like ramp-up organization and controlling to offer organizations alternative approaches. The presented methods and instruments are not exhaustive but represent a selection of methods with implications for ramp-up management.

Based on these limitations, future research directions should test the deduced hypotheses and include the elaboration of each proposed instrument in the context of ramp-up management. This requires an operationalization of the dependent variables of the proposed framework (that is, ramp-up performance and serial production stability) and the implementation of the proposed HR methods in ramp-up projects. Topics of interest are specific competency profiles that ramp-up managers, ramp-up team members, and production workers should possess to perform successfully in ramp-up projects. Furthermore, design and testing of training programs that are aimed at the development of those competencies in employees would provide organizations with useful and practical information. Once the required competencies are identified, specific selection instruments can be either developed or adapted from other existing and established instruments. The systematic identification and development of relevant competencies would belong, for instance, to the concept "competency modeling" within the proposed framework. Further relevant research would include a comparison of ramp-up projects that were established under the application of specific instruments (for example, communities of practice) with project teams without specific interventions. Also, empirical work regarding the effectiveness of reward systems in ramp-up phases needs further elaboration. For instance, it is not clearly understood yet which performance criteria are useful or harmful and which level of allocation is most effective in increasing ramp-up performance. Overall, the presented framework serves as a general starting point for incorporating HR methods into ramp-up management, but the specific effects of these methods on the outcome variables require empirical testing.

ACKNOWLEDGMENT

The support of the German National Science Foundation (Deutsche Forschungsgemeinschaft DFG) through the funding of the research training group "Ramp-Up Management – Development of Decision Models for the Production Ramp-Up" (1491/2) is gratefully acknowledged.

REFERENCES

Abele, E., J. Elzenheimer, and A. Rüstig. 2003. Anlaufmanagement in der serienproduktion. *Zeitschrift für wirtschaftlichen Fabrikbetrieb* 98, no. 4:172–76.

Anderson, N., F. Lievens, K. van Dam, and A. M. Ryan. 2004. Future perspectives on employee selection: Key directions for future research and practice. *Applied Psychology: An International Review* 53, no. 4:487–501.

Bartol, K. M., and A. Srivastava. 2002. Encouraging knowledge sharing: The role of organizational reward systems. *Journal of Leadership & Organizational Studies* 9, no. 1: 64–76.

Basse, I., S. Schmitt, T. Gartzen, and R. Schmitt. 2014. Solution principles for managing instabilities in ramp-up. *Procedia CIRP* 20:93–97.

Bischoff, R. 2007. *Anlaufmanagement: Schnittstelle zwischen projekt und serie.* Konstanzer Managementschriften 2. Konstanz: Hochschule Konstanz.

Bonebright, D. A. 2010. 40 years of storming: A historical review of Tuckman's model of small group development. *Human Resource Development International* 13, no. 1:111–20.

Bruns, H. 2010. *Organisation des anlaufmanagements.* Schriftenreihe des Instituts für Werkzeugmaschinen und Fertigungstechnik der TU Braunschweig, Essen: Vulkan-Verl.

Clardy, A. 2008. Human resource development and the resource-based model of core competencies: Methods for diagnosis and assessment. *Human Resource Development Review* 7, no. 4:387–407.

Cox, A. 2005. What are communities of practice? A comparative review of four seminal works. *Journal of Information Science* 31, no. 6:527–40.

Dahlgaard-Park, S. M., C. Chen, J. Jang, and J. J. Dahlgaard. 2013. Diagnosing and prognosticating the quality movement: A review on the 25 years quality literature (1987-2011). *Total Quality Management & Business Excellence* 24, no. 1/2:1–18.

Davis, A., and J. Scully. 2008. Strategic resourcing. In *Strategic Human Resource Management,* 95–128. United Kingdom: The Aston Centre for Human Resources.

Day, D. V. 2000. Leadership development: A review in context. *The Leadership Quarterly* 11, no. 4: 581–613.

DeSimone, R. L., and J. M. Werner. 2012. *Human resource development,* sixth edition. International ed. Australia: South-Western/Cengage Learning.

Dombrowski, U., and T. Hanke. 2011. Lean ramp-up: Schwerpunkte im anlaufmanagement. *Zeitschrift für wirtschaftlichen Fabrikbetrieb* 106, no. 7:531–35.

Drezner, J. A., and M. Huang. 2009. On prototyping: Lessons from RAND research. Santa Monica, CA: Rand Corporation.

Ellström, P. 1997. The many meanings of occupational competence and qualification. *Journal of European Industrial Training* 21, no. 6: 266–73.

Fitzek, D. 2006. Anlaufmanagement in netzwerken: Grundlagen, erfolgsfaktoren und gestaltungsempfehlungen für die automobilindustrie. *Schriftenreihe Logistik der Kühne-Stiftung* 8. Bern [u.a.]: Haupt.

Fjällström, S., K. Säfsten, U. Harlin, and J. Stahre. 2009. Information enabling production ramp-up. *Journal of Manufacturing Technology Management* 20, no. 2:178–96.

Frey-Luxemburger, M. 2014. *Wissensmanagement - Grundlagen und praktische anwendung: eine einführung in das IT-gestützte management der ressource wissen.* Wiesbaden: Springer Fachmedien.

Gerhards, S., and B. Trauner. 2010. *Wissensmanagement: 7 Bausteine für die Umsetzung in der Praxis* 4. Aufl. Pocket-Power 032. München: Hanser.

Gnahs, D. 2010. *Kompetenzen - Erwerb, erfassung, instrumente.* Studientexte für Erwachsenenbildung, Bielefeld: Bertelsmann.

Haas, M., D. Hermenau, and A. Romberg, eds. 2005. *Der Anlaufmanager.* Stuttgart: LOG_X.

Haller, M. 2003. Cycle time management during production ramp-up. *Robotics and Computer-Integrated Manufacturing* 19, no. 1-2:183–88.

Heine, I., R. Schmitt, and P. Beaujean. 2015. Critical incidents of quality orientation in lower and middle management. In *The 8th International Working Conference Total Quality Management - Advanced and Intelligent Approaches,* ed. V. D. Majstorovic, 51–56. Belgrade/Serbia: Mechanical Engineering Faculty, Laboratory for Production Metrology and TQM.

Heinsman, H., A. H. de Hoogh, P. L. Koopman, and J. J. van Muijen. 2007. Competencies through the eyes of psychologists: A closer look at assessing competencies. *International Journal of Selection and Assessment* 15, no. 4:412–27.

Held, T. 2009. Anlaufmanagement in der fast moving consumer goods industries. *PPS-Management* 14, no. 1:37–40.

Herrmann, C., A. Wenda, and H. Bruns. 2008. Einsatz des viable system model im anlaufmanagement. *Zeitschrift für wirtschaftlichen Fabrikbetrieb* 103, no. 10:691–95.

Karau, S. J., and K. D. Williams. 1993. Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology* 65, no. 4:681–706.

Koren, Y., U. Heisel, F. Jovane, T. Moriwaki, G. Pritschow, G. Ulsoy, and H. van Brussel. 1999. Reconfigurable manufacturing systems. *CIRP Annals - Manufacturing Technology* 48, no. 2:527–40.

Kormanik, M. B., R. D. Lehner, and T. A. Winnick. 2009. General competencies for the HRD scholar-practitioner: Perspectives from across the profession. *Advances in Developing Human Resources* 11, no. 4: 486–506.

Laick, T. 2003. Hochlaufmanagement - Sicherer produktion-shochlauf durch zielorientierte gestaltung und lenkung des produktionsprozesssystems. In *Produktionstechnische Berichte aus dem FBK,* ed. J. C. Aurich 47. Kaiserslautern.

Landy, F. J., and J. M. Conte. 2010. *Work in the 21st century: An introduction to industrial and organizational psychology,* third edition. Malden, MA. Wiley-Blackwell.

Lee, Y. 2009. Competencies needed by Korean HRD master's graduates: A comparison between the ASTD WLP competency model and the Korean study. *Human Resource Development Quarterly* 20, no. 1:107–33.

Lenfle, S., and C. Midler. 2009. The launch of innovative product-related services: Lessons from automotive telematics. *Research Policy* 38, no. 1:156–69.

Lucia, A. D., and R. Lepsinger. 1999. *The art and science of competency models: Pinpointing critical success factors in organizations*. San Francisco, CA: Jossey-Bass/Pfeiffer.

Mullins, L. J. 2010. *Management and organisational behaviour*, ninth edition. Harlow: Financial Times Prentice Hall.

Risse, J. 2003a. *Supply chain steuerung und services. Logistikdienstleister managen globale netzwerke - Best practices*. Berlin: Springer.

Risse, J. 2003b. Time-to-market management in der automobilindustrie: Ein gestaltungsrahmen für ein logistikorientiertes anlaufmanagement. In *Schriftenreihe Logistik der Kühne-Stiftung*. Bern, Stuttgart, Wien: Haupt.

Robbins, S. P. 1996. *Organizational behavior: Concepts, controversies*, applications, seventh edition. Englewood Cliffs, NJ: Prentice Hall.

Salgado, J. F., C. Viswesvaran, and D. S. Ones. 2001. Predictors used for personnel selection: An overview of constructs, methods and techniques. In *Handbook of Industrial, Work and Organizational Psychology*, eds. N. Anderson, D. S. Ones, H. K. Sinangil, and C. Viswesvaran, 165–99. London: Sage.

Schmidt, F. L., and J. E. Hunter. 1998. The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin* 124, no. 2:262–74.

Schmitt, S., and R. Schmitt. 2011. Entrepreneurial quality management: Conception of a process model for a quality-oriented production ramp-up. In *Proceedings of the 16th Annual International Conference on Industrial Engineering, Theory, Application and Practice, Stuttgart*.

Schmitt, S., and R. Schmitt. 2013. Lifecycle oriented ramp-up: Conception of a quality-oriented process model. In *Re-engineering manufacturing for sustainability: Proceedings of the 20th CIRP International Conference on Life Cycle Engineering, Singapore 17-19 April, 2013*, eds. Nee, A. Y. C, Bin Song, and Soh-Khim Ong, 441–45. Singapore: Springer.

Schuh, G., W. Stölzle, and F. Straube, eds. 2008. *Anlaufmanagement in der Automobilindustrie erfolgreich umsetzen: Ein leitfaden für die praxis*. 1. Aufl. VDI-Buch. Berlin: Springer Berlin.

Shipton, H., and Q. Zhou. 2008. Learning and development in organisations. *Strategic Human Resource Management*, 159–88. United Kingdom: The Aston Centre for Human Resources.

Specht, D., R. Stefanska, and C. M. Gruß. 2008. Objektorientierter ansatz zur kostenbeeinflussung in den frühphasen der produktentstehung. *Zeitschrift für Wirtschaftlichen Fabrikbetrieb* 103, no. 5:311–15.

Srinivasan, V., W. S. Lovejoy, and D. Beach. 1997. Integrated product design for marketability and manufacturing. *Journal of Marketing Research* 34, no. 1:154.

Sturdy, A. 2012. Knowledge and learning: Consuming management. In *Introducing organizational behaviour and management*, eds. D. Knights and H. Willmott, 196–237. Andover, Hampshire, U.K. Cengage Learning EMEA.

Tani, T., and S. Wangenheim. 1998. Vergleichende empirische analyse des serienanlaufs bei automobilzulieferern in Deutschland und Japan. In *Integrationsmanagement für neue Produkte*, eds. Péter Horváth, 23–53. Schriftenreihe der Schmalenbachgesellschaft - Deutsche Gesellschaft für Betriebswirtschaft e.V. Stuttgart: Schäffer-Poeschel.

Terwiesch, C., R. Bohn, and K. Chea. 2001. International product transfer and production ramp-up: A case study from the data storage industry. *R&D Management* 31, no. 4:435–51.

Terwiesch, C., and Y. Xu. 2004. The copy-exactly ramp-up strategy: Trading-off learning with process change. *IEEE Transactions on Engineering Management* 51, no. 1:70–84.

Tuckman, B. W., and M. A. Jensen. 1977. Stages of small-group development revisited. *Group & Organization Studies* 2, no. 4:419–27.

Wheelwright, S. C., and K. B. Clark. 1992. *Revolutionizing product development: Quantum leaps in speed, efficiency, and quality*. New York: Free Press.

BIOGRAPHIES

Ina Heine obtained her master's degree in work and organizational psychology from Maastricht University, Netherlands, in 2012. She is currently working as a research assistant at the Chair for Metrology and Quality Management of RWTH Aachen University, Germany, and writing her doctoral thesis. Her research interests include organizational culture, human resource methods, human performance, and leadership. She can be reached by email at I.Heine@wzl.rwth-aachen.de.

Patrick Beaujean is head of the Department of Quality Management at the Laboratory for Machine Tools and Production Engineering (WZL) where he is responsible for the international cooperation with the German University of Technology (GUtech) in Oman on behalf of RWTH Aachen University, Germany. His research interests include quality-oriented organizational development and higher education structures in an international context.

Robert Schmitt is a professor of metrology and quality management at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University, Germany, and since 2005 he is member of the board of directors at the Fraunhofer Institute for Production Technology IPT. He received his doctorate degree from the faculty for mechanical engineering at the RWTH Aachen University in 1999. His main research interest is production-related metrology and communications engineering in an automatized environment.

Executive Briefs

Improving Production Ramp-Up Through Human Resource Methods (pp. 7–19). Ina Heine, Aachen University; Patrick Beaujean, Aachen University; and Robert Schmitt, Aachen University

The performance of an organization in the ramp-up phase of manufacturing strongly impacts the quality of the serial production, contributing to important manufacturing performance measures that are relevant to both production and quality managers. Performance improvements in production ramp-up, however, are difficult to achieve, as there are numerous challenges to overcome due to unpredictable system behavior.

In order to improve the stability of production ramp-up, the authors of this article propose applying human resource (HR) methods. Based on theory and well-known concepts in the field, they developed a framework of HR methods for ramp-up management. These six methods include knowledge management, competency modeling, reward systems, leadership development, employee selection, and team development. This framework provides quality managers with methods for improving quality-related outcomes that are less technical and more human centered.

While the practical implications of these HR methods are not clear since empirical research is limited, the authors expect that the result of applying the proposed framework is project teams meeting their ramp-up targets more probably. In the long term, they expect an increase in serial production stability.

A Framework to Identify Best Quality Management Practices and Techniques for Diverse Production Ramp-Up Environments: Propositions for Future Research (pp. 20–44). Zachary Moran Leffakis, Clemson University

There is great strategic and financial incentive for manufacturing firms to decrease their new product time-to-market and time-to-volume, as being the first to introduce new products to the market brings a firm a unique leadership sales position that enhances a firm's potential to sell at higher prices and volumes. This, in turn, results in greater market share, a competitive advantage, and greater profitability.

Over the years there has been much research regarding methods and approaches for decreasing new product development time. A rather new area of research is that of ramp-up management. Researchers are beginning to explore how the myriad relationship of competitive variables and operational factors can have an impact on the cost, quality, and timeliness in the production ramp-up phase. This article aims to develop a framework to categorize four different types of production ramp-up environments across various manufacturing settings. The research framework seeks to identify the best quality management practices manufacturers can apply to prevent production ramp-up disturbances and improve yield rate performance. It is argued that each environment exhibits different levels of uncertainty, complexity, and operational characteristics, requiring a unique strategy with an exclusive set of quality management practices and techniques to improve production ramp-up performance.

Lean Applications to Manufacturing Ramp-Up: A Conceptual Approach (pp. 45–54). Irene Christensen, Copenhagen Business School, and Anna Rymaszewska, University of Vaasa

The two concepts of lean and ramp-up are generally associated with dissimilar environments, as lean is viewed as applicable to high-volume, low-variability manufacturing, while the ramp-up phase is noted for its short-term focus, unpredictability, and complexity. This paper attempts to suggest the benefit of applying lean principles during the final stage of the new product