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Boosting Innovation in Factory Of the future value Chain in the Alps

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D.T3.3.1: Set of guidelines to integrate impact indicators to innovation processes

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EXECUTIVE SUMMARY

The present paper concludes the last activity of WPT3 and completes the framework of the impact indicator system. While the previous deliverables cover the elaboration and evaluation of the impact indicator system, the deliverable D.T3.3.1 focuses on the development of guidelines to successfully integrate the framework in companies. The guidelines are defined from a companies' perspective, proposing good practices regarding the adaption of the impact indicator system to the organizational structure as well as its correct application. The results of the workshops, held in activity A.T3.2 provide critical input to the development of guidelines. Additionally, a literature research was performed in order to include already existing approaches and recommendations in the development of guidelines.

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1 INTRODUCTION

1.1 Activities and deliverables

This deliverable presents the last of three activities in WPT3, as shown in Figure 1. The deliverable strongly builds upon the specific outcomes of the previous activities, especially on the definition of the impact indicator system in activity A.T3.1 and its evaluation performed in activity A.T3.2. As specified in Figure 1, this paper aims to present a set of guidelines in order to successfully implement the impact indicator system in companies. The guidelines are developed from a company's perspective, addressing specific steps to be considered in the implementation process. A more policy-orientated perspective is pursued in the following working package WPT4.

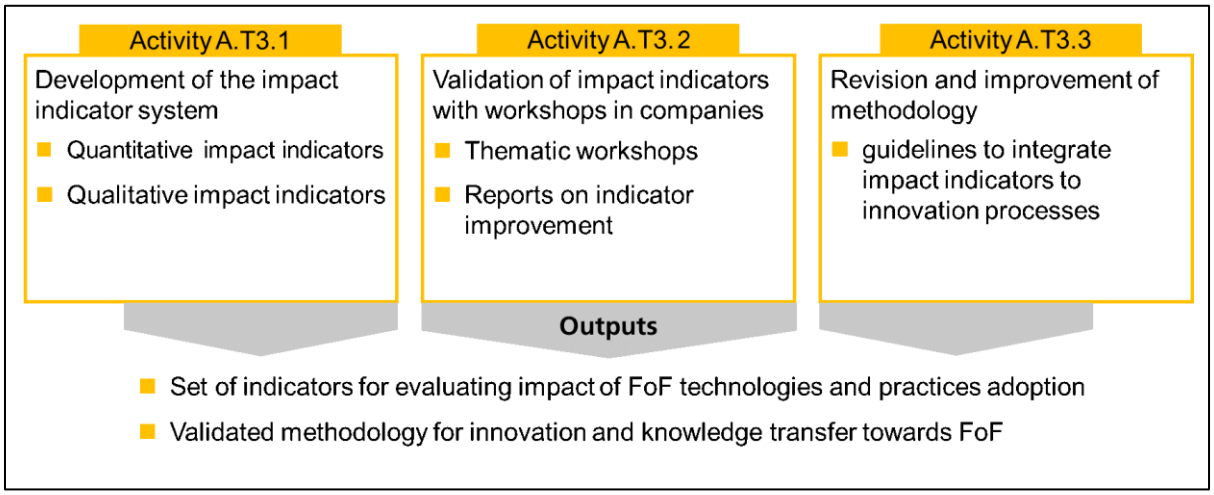

Figure 1: Activities and deliverables in WPT3

1.2 Approach

The development of guidelines to successfully adopt the impact indicator system is based on several factors. The guidelines strongly depend on the specific structure of the impact indicator system together with its relation to the internal and external environment of the company. Likewise, specific experience and inputs from industrial partners is considered in the formulation process, which was obtained in two workshops in activity A.T3.2. Finally, the development process rests on already existing literature addressing the integration of performance measurement systems in companies.

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Due to the mentioned dependence of the guidelines on the structure of the impact indicator system and the workshop results, this paper starts with a short reiteration of the impact indicator system. Subsequently, the most important findings from the workshop are presented together with their relevance and importance for this deliverable. In chapter 4, the guidelines are presented and described in detail. The deliverable concludes with a short summary of the developed methodology.

2 IMPACT INDICATOR SYSTEM - RECAPITULATION

The impact indicator system aims to support the transformation of manufacturing companies towards a factory of the future (FoF) by proposing a set of both quantitative and qualitative key performance indicators (KPI). The framework is built on multiple methods, combining a qualitative maturity assessment with indicators on different levels according to the Input-Process-Output-Outcome (IPOO)-framework.

The IPOO-framework proposes to allocate and define KPIs on four different levels in order to consider multiple perspectives in a performance measurement system. This enables the user to look beyond financial figures in order to track the total impact of FoF-technology adoption according to the specific objectives of activity A.T3.1. The IPOO-framework defines the four categories *Inputs, Processing System, Outputs* and *Outcomes*. The category *Inputs* represents factors entering the system, such as resources, facilities, information, etc. In contrast. The following three categories outline KPIs to measure short term impacts, such as process improvements, up to long term long term results relevant for the overall success and the mission of the company. The category *Processing System* processes the inputs entering the system, generating *Outputs* such as new products, processes, patents, knowledge or new methods. These *Outputs* are critical for the long term monetary, market- and customer related success, which is measured in the last category *Outcomes*. In the deliverable D.T3.1.1, several KPIs are presented that can be selected to measure the impact in the last three categories of the IPOO-framework.[1]

Besides of the IPOO-framework, the impact indicator system builds on activities performed in previous working packages, especially on the definition of critical success factors, which represent main enablers for FoF practices- and technology adoption.

[1] Refer to D.T3.1.1 for detailed information

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The critical success factors cover the following criteria, as shown in Deliverable D.T2.2.1:

- CSF1: Strategy
- CSF2: Technology
- CSF3: Capacity for innovation
- CSF4: Ecosystems support for innovation
- CSF5: Skills and change management

In WPT2, each success factor consists of five maturity levels, which define certain requirements an enterprise has to achieve in order to advance in their maturity levels. Referring to the impact indicator system, these maturity levels allow the formulation of company-specific objectives, which can further support the decision-making process regarding future developments and investments. In summary, the maturity levels of the critical success factors cover specific FoF-technologies but also necessary skills, requirements, practices and other steps a company needs to invest in, in order to develop itself to a factory of the future. Accordingly, these critical success factors are suited to represent the category *Inputs* in the IPOO-framework linking specific FoF investments with achieved outcomes.[2]

According to the specifications described above, the first part of the impact indicator system consists of a qualitative maturity assessments in accordance with the definition of critical success factors. The second part of the impact indicator system includes quantitative KPIs allocated to the categories *Processing System, Outputs* and *Outcomes.* The fundamental structure of the impact indicator system is shown in in Figure 2

[2] Refer to D.T3.1.2 for detailed information

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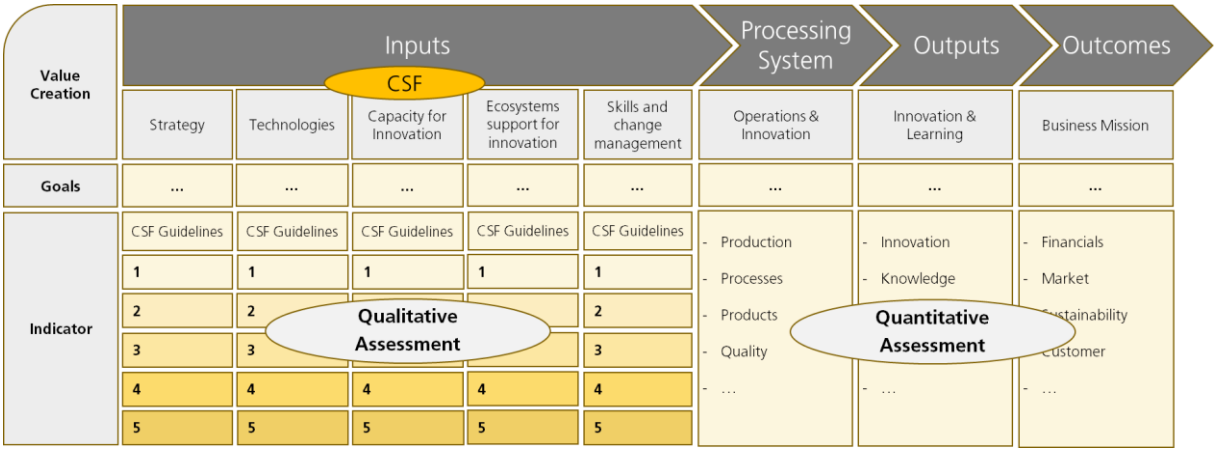

Figure 2: Impact indicator system

3 WORKSHOP RESULTS

In activity A.T3.2, two workshops were organized aiming at presenting the developed impact indicator system to representatives from industry and discussing its applicability in practice. The outcomes of these workshops pose critical inputs for the development of guidelines in this deliverable.

3.1 Research questions

Both workshops differ more or less concerning the specific research questions underlying the workshops. While the first workshop held in Vienna specifically focused on validating specific contents of the impact indicator system, the workshop in Stuttgart offered a more technical perspective, discussing the integration of FoF-technologies in companies. The results of the first workshop are particularly interesting for the development of guidelines.

In both workshops, the discussions were organized in form of world-café sessions, thus guaranteeing a high participation rate of the workshop participants. In three rounds lasting 15 minutes, the participants got the opportunity to discuss three different research questions, which are stated in Table 1 and Table 2.

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Table	Research questions – Workshop Vienna	
Table 1	*Q1.*	*What are critical framework conditions for companies in order to successfully manage the transition towards the "factory of the future?*
Table 2	*Q2.1*	*Do you actively cooperate with companies (Exchange of experience, networking, etc.) in the area of the "factory of the future?*
	Q2.2	*How actively are you conducting research activities?*
Table 3	*Q3.1*	*Which indicators and performance measures are used in your company?*
	Q3.2	*Do you use performance measures to evaluate and control topics concerning the "factory of the future*

Table 1: Research questions – Workshop Vienna

Table	Research questions – Workshop Stuttgart	
Table 1: Virtual Prototyping	*Q1.1*	*„Do you use KPIs during the technology implementation process?"*
	Q1.2	*How do you proceed with the technology selection? Are there any evaluation criteria / methods that are used?"*
	Q1.3	*"What are the technical requirements for an introduction of a new technology?"*
Table 2: Service and Maintenance	*Q2.1*	*„Why are technologies being introduced?"*
	Q2.2	*„What are the technical requirements for an introduction of a new technology?"*
	Q2.3	*"What are potential hurdles (from a technical, business and cultural point of view) in the introduction of technology?"*
Table 3: Product Design and Marketing Communication	*Q3.1*	*„Why are technologies being introduced?"*
	Q3.2	*"Which qualitative aspects must be given in the technology introduction?"*
	Q3.3	*"What are potential hurdles (from a technical, business and cultural point of view) in the introduction of technology?"*

Table 2: Research questions – Workshop Stuttgart

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3.2 Results and relevance for the development of guidelines

In the following, the results of the workshops are presented in form of main insights for both workshops. The importance and relevance of the results for the development of guidelines is then summarized in a short paragraph.

Workshop Vienna main insights – Table 1	
1	Industry 4.0 & Factory of the Future paradigm heavily relates to organizational strategy
2	Employee participation and motivation are key elements for a successful transition towards a factory of the future
3	Evolving to a smart service Factory of the Future highly depends on the organizational capability for innovation
4	A strong interplay between the presented critical success factors exists

Table 3: Workshop Vienna main insights – Table 1

Table 1 dealt with the first part of the impact indicator system, namely the qualitative self-assessment using the list of critical success factors defined in WPT2. The research question aimed at validating the completeness of the critical success factors through inputs from practice. As visible from Table 3, the workshop participants almost completely agreed with the chosen approach in the impact indicator system. Large parts of the main insights stated in Table 3 correspond to the list of critical success factors. A special focus was put on the importance of organizational strategy to support the transition towards a factory of the future. This factor will be of importance in the development of guidelines for the impact indicator system. The successful integration of the impact indicator system in companies requires continuous monitoring and a high degree of devotion in order to use the tool efficiently. This in turn is only feasible with a supportive company strategy.

The workshop participants also discussed, that the critical success factors cannot be seen independent of each other. Improvements in one category directly affect the other success factors. Nevertheless the participants agreed, that the list of success factors offers a suitable approach to categorize the main requirements towards a factory of the future. The high rate of accordance from workshop participants justifies the chosen approach.

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Workshop Vienna main insights – Table 2	
1	Qualification
2	Dependencies by cooperations
3	IT Safety and Security – Limitation fact for cooperation
4	Research activities vs. Quick wins

Table 4: Workshop Vienna main insights – Table 2

Table 2 in the world café session provided a lot of information concerning research and development activities and the need for cooperation in a globalised world. Generally, small and big companies see big cooperation potentials in holistic approaches. Big companies often are slow and sluggish in opposite to e.g. startups, trying new, innovative and visionary concepts and technologies in the sector of I4.0. So they try to cooperate with Startups or moreover, fund spin-offs to get shorter development and testing cycles. Successful cooperation in the field of I4.0 generally requires appropriate economic framework conditions. While the need for cooperation is a major topic in the impact indicator system, establishing a proper environment and framework conditions lies not in the scope of this working package.

The workshop participant further stated the importance of quick wins in the implementation process of new technologies. This helps to win the confidence of employees, guaranteeing employee motivation and participation. The impact indicator system meets these requirements as its scope lies in revealing short-term as well as long-term impacts on different levels of the company.

Workshop Vienna main insights – Table 3	
1	Only “classical” measures are used in companies
2	Focus of measures: Financial benchmarking
3	Only a few measures are used in the management of a company
4	Concerns of using measures in the decision-making process
5	No single company is using measures to track their path towards FoF

Table 5: Workshop Vienna main insights – Table 3

The research questions of the third table in the world café session focused on evaluating the overall importance of performance indicators in SMEs. On the other hand, the discussions aimed at identifying specific measures in context of FoF-related

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topics. Table 5 shows that companies, especially SMEs, are still reluctant to using performance measures for decision-making and on the path towards the FoF, due to the high information loss of most indicators. Mostly, indicators are used solely to track the overall financial success of a company. The most common cause related to the low level of KPI-integration concerns the company-specific selection of indicators. Many SMEs have limited information on which indicators to choose. Additionally, a lack of sufficient data limits the range of suitable for many companies.

The results from this world café discussion confirm the necessity to develop a framework, which manufacturing companies can use to support the path towards FoF. The impact indicator system offers a proper reference system, providing profound information on a sound and appropriate indicator selection in context of FoF. Activity A.T3.1 provides a set of indicators for each level of the impact indicator system, covering more than financial topics from short-term and long-term perspectives. These indicators need to be adjusted for each company according to specific objectives and the data available. The selection process of proper indicators is highly relevant for the development of guidelines in chapter 4.

Workshop Stuttgart main insights	
1	Technology applications should be easy to handle for people and workers
2	Data integration from existing data into the new application has to possible in a very smooth way
3	Technology providers have to ensure data security especially in manufacturing and engineering processes, in which a lot of companies have their intellectual property
4	The main requirements the discussion groups identified on a policy maker level is providing a stable and fast connection to the internet
5	To fasten technology implementation in companies a pilot testing phase for companies seems a good way to test the advantages of digital technologies
6	Technology implementation should fit into the organizational structure and employees also have to be part of the implementation process
7	For SMEs it is difficult to evaluate the benefits of a digital solution beforehand. A set of guidelines would be helpful

Table 6: Workshop Stuttgart main insights

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In comparison to the workshop held in Vienna, the workshop in Stuttgart has a more specific focus on technology integration in companies, instead of validating the impact indicator system. The results are still important for the development of guidelines in chapter 4, as the path towards FoF is characterized by technology integration. An important insight of this workshop indicates, that Technology implementation has to fit into the organizational structure and employees also have to be part of the implementation process. The impact indicator system represents a framework, not a complete and finished system. The framework needs to be adapted to the specific needs and requirements of the respective company, regarding the selection of indicators and the definition of goals. It can therefore be adapted to the organizational structure of the company. The role of employees, addressed in Table 6, needs to be considered in the implementation process of the impact indicator system. This will be a critical input to the development of guidelines.

Table 6 also highlights, that SMEs have difficulties in evaluating the benefits of a digital solution beforehand. The structured approach of the impact indicator system covering multiple perspectives, allows companies to allocate possible impacts on different levels. This enables companies to split the total impact into smaller, more specific topics, thus allowing to estimate possible impacts of new technologies beforehand.

4 METHODOLOGY FOR INTEGRATION - GUIDELINES

This section presents a framework, consisting of multiple consecutive guidelines, to integrate the impact indicator system into practice. The development of guidelines is based on previous deliverables of WP3, the results of the workshops described in chapter 3 as well as a systematic literature research. The guidelines are defined from a companies' perspective, proposing good practices regarding the adaption of the impact indicator system to the organizational structure as well as its correct application.

According to the structure of the impact indicator system, the guidelines are clustered into three main areas:

- Qualitative self-assessment
- Selection of quantitative indicators
- Integration and application

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While the first two areas relate to setting up the impact indicator system, the last area represents the continuous application in the company.

1. Qualitative self-assessment

The implementation of the impact indicator system in manufacturing companies starts with a formulation of goals and objectives, a company wants to achieve regarding FoF. Long-term objectives have to be translated into operational objectives. This step is critical in order to create a common understanding of the related challenges and to take the company strategy into account before applying the indicator system. As the path towards FoF is characterized by strategic decision making, a company needs to choose indicators that reflect the company strategy. This is only possible, if strategic goals are defined in advance. The first guideline for the implementation process can be defined as:

GL 1.1. Development of a common understanding regarding strategic objectives and goals in context of FoF

Following the definition of goals and objective, the company can start with the first part of the impact indicator system, namely the qualitative maturity evaluation, according to the set of critical success factors. Each success factor proposes five consecutive maturity levels, companies should achieve, in order to advance to a factory of the future. According to these success factors, manufacturing companies can analyse their current maturity levels. The assessment is necessary to identify the initial position of the respective company. The second guideline is therefore:

GL 1.2. Perform the qualitative maturity assessment according to the definition of critical success factors towards FoF

Based on the results of the maturity analysis as well as the definition of strategic goals, the company can now identify areas of activity, where additional inputs are required such as financial resources, employee training, recruitment activities, technology development, etc. Providing these inputs is necessary to increase the maturity level in the respective success factors and to reach the objectives defined previously. The identification of special fields of action further forms the basis for the definition of quantitative indicators to track improvements of technology and practices adoption. Accordingly, the third guideline regarding the qualitative part of the impact indicator system reads as follows:

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2. Selection of quantitative indicators

The preceding maturity assessment together with the definition of critical areas of activity is necessary to derive appropriate indicators to track the impact of technology and practices adoption towards FoF. The indicators have to be selected based on the three levels *Processing System, Outputs* and *Outcomes* presented in chapter 2. *Tonchia & Quagini* propose an approach for effective indicator selection, which can serve as an orientation to derive, implement and manage suitable indicators for the impact indicator system.

A broad range of indicators is available to measure and track various issues and situations. According to *Tonchia & Quagini*, one way to isolate the different characteristics of indicators is to refer to following sequence of adverbs:

- *What* to measure?
- *Whom* to measure?
- *Who* measures?
- *To Whom* to report the measures?
- *Why* to measure?
- *How* to measure?
- *When* and *How often* to measure?
- *How much* or at what cost?[3]

Regarding the composition of the impact indicator system, it is important for companies to select indicators that optimally reflect the previously defined strategic objectives as well as the identified areas of activity. For example, a company that has detected a tremendous need to develop its workforce regarding FoF-related qualifications, should put effort into identifying indicators that are suitable to track the employee development over time. The deliverable D.T3.1.1 offers a set of possible indicators for each level of the impact indicator system *Processing System, Outputs* and *Outcomes.* The first guideline regarding the selection of quantitative indicators can be defined as:

[3] Cf. Tonchia und Quagini, 2010 S.62

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GL 2.1. Initial screening and preselection of suitable indicators reflecting the strategy to measure the impact of technology and practices adoption

Following a preliminary selection of suitable indicators, companies now have to evaluate, if the necessary resources are available to enable the incorporation of an indicator in the impact indicator system. Major subjects of investigation include:

- The availability of data
- Possible difficulties in integrating the new indicator within the existing system
- The adaptability of the indicator from a short and long term point of view
- The development process, reviews and changes to measures
- The availability of persons with suitable skills and expertise to implement and use such measures
- Information systems which are able to collect, analyse and report data and measures
- The “measurement culture” within the company which must be able to express the value, relevance and importance of measurements and measures
- Etc.[4]

The evaluation of the topics above further helps to perform a cost-benefit analysis, which determines if the inclusion of indicators is worth the effort. In a major part of companies, most decisions are based on such cost-benefit analysis. Accordingly, an applicability study is of great importance to filter final indicators, which fulfil the system requirements and guarantee an efficient and effective application of the impact indicator system in companies. The second guideline therefore reads as follows:

GL 2.2. Applicability study for each indicator to evaluate critical requirements, which determine the incorporation of indicators in the indicator system

Once suitable and final indicator are selected for the three levels *Processing System, Outputs* and *Outcomes*, the indicator system will be subjected to formalisation procedures according to complete and homogenous standards. *Tonchia & Quagini* propose, that an electronic spreadsheet can be as the basis for implementing IT systems from an operational point of view. Spreadsheets are suitable to display the

[4] Cf. Tonchia und Quagini, 2010 S.63 f.

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individual indicators in lines, grouped by performance dimensions and business area, and columns, including specifications such as:

- Dimensions ("cost" or "non-cost")
- Type (quantity, cost, productivity, quality, service, time, etc.)
- Other features such as internal/external and short/long term
- Units of measure
- Formula of the indicator
- Existing and where implemented
- Non-existent, but data are already available to calculate the measures or not
- Target value if applicable
- The source of the data (ERP, data-base, hard copies)
- The reference period
- Frequency of data collection
- Periodic improvement percentage
- The business unit being evaluated
- The person performing measurement procedures or the automatic measurement procedure
- The user business unit, the type of use, and who else has this information
- Etc.[5]

The result of this formalisation process is a complete and self-contained listing of the indicators included in the impact indicator system, which guarantees a high degree of transparency for all individuals involved. This provides a good starting point for the successful application of the indicator system. The corresponding guideline is therefore:

GL 2.3. Formalisation of the final list of indicators according to complete and homogenous standards in order to provide all necessary information to all individuals involved

[5] Cf. Tonchia und Quagini, 2010 S.62 f.

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3. Integration and application

The first 6 guidelines elaborated above are beneficial to adapt the impact indicator system to the requirements, objectives and specific needs of each company. The last set of guidelines concerns the successful application and maintenance of the measurement system over time. The insights and findings gained through the intensive exchange with SMEs (workshops) are particularly relevant for this subchapter.

Collecting the required data and maintaining the impact indicator system over a long period is a time-consuming and complex process. In order to sustain this process until the target state is achieved, it is important to secure a continuous support from the top-management level. As employees tend to follow their supervisors regarding the adoption of new methods and changed ways of thinking, tasks related to the impact indicator system should be introduced in a top-down process to the responsible individuals. One issue for the integration of the impact indicator system concerns the adoption of the indicator system to the company strategy. Yet, another issue concerns aligning the company strategy to the path towards FoF, which is necessary to secure a high degree of devotion from the top-management. The company strategy should also earmark the use of tools like the impact indicator system, in order to achieve the desired state. The first guideline for a successful application can be defined as follows:

GL 3.1. Alignment of the company strategy towards FoF and to the use of indicators in order to secure full top-management support

In order to succeed on the path towards FoF, a company needs to take into account the role of every employee involved in the project. Providing sufficient information and raising awareness regarding upcoming activities towards FoF, is a main enabler to increase employee motivation and participation in the change process. Stakeholders need to be aware of their purpose and how the application of the impact indicator system affects them. For this reason, a reasonable step lies in developing a communication framework in order to communicate the company strategy as well as possible changes in a fast manner to all employees. Besides establishing a communication framework, presentations and trainings offer another opportunity to achieve an institutionalisation of the impact indicator system in the company. These are helpful to convey the benefits of the indicator system, which, in turn supports a continuous application and maintenance of the indicator system. Accordingly, the second guideline is:

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GL 3.2. Establishment of communication structures and organization of training activities (presentations) to convey the benefits of the indicator system in order to secure the support from all individuals

The impact indicator system is not designed to be applied for a singular analysis. In order to achieve the desired effect, it is important to consider the framework as a continuous management tool that needs to be applied and maintained, until the objectives are reached. Therefore, clear responsibilities have to be assigned, especially concerning the data collection and the evaluation of results. The application of the framework can be demonstrated as illustrated in Figure 3. Based on the adaption of the impact indicator system to the strategic objectives of the company, the company identifies fields of action according to the set of critical success factors, equivalent to the guidelines GL1.1, GL1.2 and GL1.3. These fields of action then serve as an orientation to make continuous improvements towards the factory of the future. The impacts of these improvements on various levels are measured using selected indicators, as described in the guidelines GL2.1, GL2.2 and GL2.3. The specific results finally enter a feedback loop, where they are compared to the strategic objectives and the critical success factors, in order to identify new fields of actions. The process is repeated, until the company achieves the desired state and the defined objectives towards FoF.

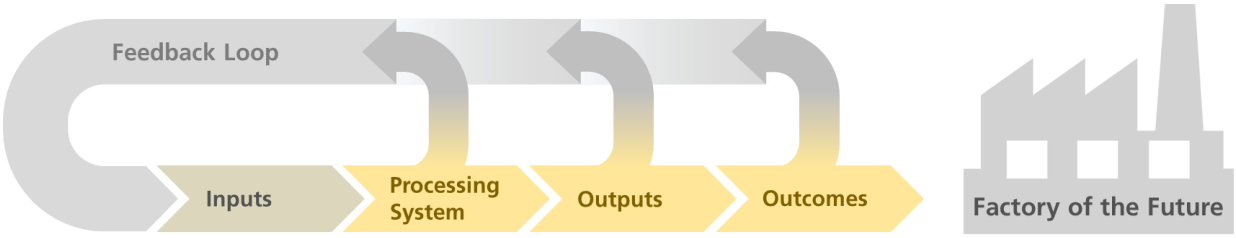

Figure 3: Application of the Impact Indicator System

According to the description of the application process above, the last guideline for a successful integration of the impact indicator system in manufacturing companies can be defined as:

GL 3.3. Continuous application and maintenance of the indicator system in order to achieve the desired results

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5 SUMMARY AND CONCLUSION

This paper presents the last deliverable of WPT3 “Set of guidelines to integrate impact indicators to innovation processes”. Based on the previous deliverables, specific insights gained from workshops with SMEs and a literature research, guidelines are developed that support a successful integration of the impact indicator system into practice. The guidelines are defined from a companies’ perspective, proposing a framework and good practices to guarantee the correct application of the impact indicator system in manufacturing companies, as the system needs to be adapted to the specific objectives and the strategy of the respective company.

This deliverable concludes the activities defined in WPT3, providing a complete and self-contained framework to track effective improvements after transfer and adoption of enabling FoF practices in manufacturing enterprises. The framework serves as a controlling tool to monitor the progress and to ensure effectiveness and efficiency of FoF in the long-term. Furthermore, it will represent a crucial input for the development of policies and strategies to boost innovation processes on a macro level in the following working package WPT4.

6 RFEFERENCES

Tonchia, Stefano und Luca Quagini. *Performance Measurement: Linking Balanced Scorecard to Business Intelligence*. Berlin Heidelberg: Springer-Verlag, 2010.

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