

# Concurrent Engineering in Practice for Small and Medium Enterprises

## Findings from Research and Industrial Pilot Cases

René STACH, Frithjof WEBER, Kulwant PAWAR, Glendon PRICE, Bruno LISANTI

*While large companies are already actively pursuing the adoption of CE principles within their business processes, there is a need for supporting Small and Medium Enterprises to evolve their organizational and cultural schemes, as well as their technological and methodological approaches towards CE. The paper outlines the approach that has been undertaken. Furthermore, it describes a Software System for the support of SMEs in the introduction of CE by self-assessment, case presentation, and tool selection. Research results for the system's application are given.*

any success stories describe the benefits which have been gained by introducing Concurrent Engineering in aircraft development. However, most cases focus on the implementation in large organisations with a major focus on product development. Long production chains offer a high potential to shorten the entire chain and thus the time-to-market. Indeed, small and medium (SMEs) companies have usually short production chains. But integrated, co-operative work with large companies has been established during the last years. This as well is a major -but often unattended- aspect of CE that is changing from Concurrent Engineering (reduction of time to market) to Concurrent Enterprising (enabling high integration among project partners) [1]. This is the theory behind CEPRA (Concurrent Engineering in Practice) bringing Concurrent Enterprising to SMEs instead of concentrating on pure technical product development.

### The approach

The CEPRA approach is twofold: The project aimed at bringing CE to SMEs by personal consulting and by a software system at the same time. Personal consulting helps to implement CE principles within the participating companies by direct interactive CE

advice. CE awareness and CE knowledge are transferred to industrial partners by universities and consultancies assisting during the defined pilot project. The software gives an instrument to the industrial partners and the consultants to measure CE performance and to support CE implementation within the company. Facts from case studies are presented and knowledge about CE tools and methods is taught.

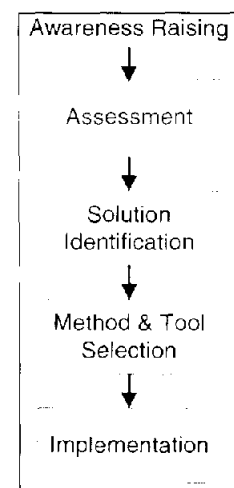
### Pilot project approach

Five pilot projects have been carried out within aeronautic SMEs in Germany, Italy, and Great Britain accompanied by human consulting and assistance in applying the software system. Thus, an CE awareness raising has been carried out during the entire pilot project taking into account experiences and guidelines from research and industry (see References – Implementation of CE). *Figure 1* describes the pilot projects' different phases.

The pilots projects start with an awareness raising session about CE principles explaining what CE means and how it can be implemented. The next three phases are accompanied by the CEPRA software which helps to create a solution for any identified problem. The implementation phase is carried out by the pilot partners in co-operation with consultants to put the identified solution into practice.

### Software system

The CEPRA Consulting Software System [2] consists of three parts. The first part is the Assessment Module (AM) assessing the SMEs' CE performance and identifying problems in the CE domain. The second part is the Solution Identifier Module (SIM) retrieving appropriate solution cases. The third part is the Tool selection Module (TSM) providing information about CE tools and methods. The AM assesses the SMEs' CE performance and optionally benchmark it against other companies or best practice assessments of different branches. The



*Figure 1. Pilot phases.*

assessment starts with approx. 60 initial questions and presents a quick provisional result. Assessment results are given for the SME's organisational structure, business strategy, process and equipment, technology deployment, knowledge and skill base as well as human empowerment. After a possible benchmark, the user decides which area(s) he wants to focus on. A second questionnaire goes into detail within the specified area(s) and gives an assessment of the following CE principles: continuous improvement, customer and supplier focus, integration, information flow, parallelism and standardisation (each questionnaire contains approx. 70 further questions). Here again the user can benchmark his results against others and/or best practice values. The entire data of his assessments are then sent to the second module. See also [3].

The TSM retrieves study cases that help to improve the SME's former assessment. Therefore, this module is based on a database with about 70 study cases that are rated against the same criteria as in the AM. The software now compares the cases data within its database with the assessment values of the SME and tries to find the most similar cases. Each retrieved study case is broken down into basic interventions (actions that have been performed in the study case) and the study case and the interventions are presented to the user. Each of the interventions is linked to a method or tool that is deemed to be helpful to put the solution within the study case into practice. This link can be done in two ways. The first is a direct link to the required information in the third software module, the second link will activate the search engine of the TSM which will retrieve all tools and methods that deal with the specified keywords.

The TSM provides information about approx. 500 tools and methods that are related to CE. Furthermore, a powerful search engine offers various options for tool and method retrieval. E.g. besides usual conjunctions (AND, OR) the search engine searches plural and singular meanings as well as different parts of speech (noun, verb, adverb, etc.). The so-called fuzzy search finds

words that sound similar to the search keywords. Synonyms are supported as well. The retrieved tools and methods come along with a short introduction, a view from a CE basis, quick criteria like price and estimated quality etc. A detailed description is provided including examples, pictures, animations, presentations, further documentation, and additional information sources (providers, journals, books) are linked. Summarising, the CEpra Consulting Software System analyses the SME's CE performance, identifies weaknesses, provides study cases whose implemented solution can overcome the weaknesses and gives information about tools and methods to put the retrieved solutions into practice.

## Results

Five industrial partners have carried out pilot projects applying the CEpra Consulting Software System. The results from these pilot projects and from the developers' experiences are given in the next section. Some are successful, some are not.

## Findings

CE awareness has been raised significantly within the SMEs [4]. The awareness raising sessions in the very beginning of the project have been very helpful to define CE and the pilot projects' scope.

## Assessment

Furthermore, the questionnaires within the Assessment Module did more than they had been supposed to. Firstly, the questionnaires did measure the CE performance of the companies subjectively good, what means that the consultants agreed with the assessment results of the software in all cases. Secondly, the questionnaires did not only transform the CE performance to comparable values, they also caused very detailed and clear discussions among the industrial partners moderated by consultants. Initially, ambiguous questions, that have later been improved, caused some queries to the developers and consultants. But then the end users started to discuss about the

usefulness of the questions and the rationale behind each question. E.g. there was the following question: "Do you agree (high points) or do you disagree (low points): Our time utilisation of key equipment is between 65 and 75%." This question caused the end users to discuss if it is good or bad to use the key equipment over 75% and they came up with examples. The developers then explained that if the usage is lower then the equipment is under used, if it is higher one may lose flexibility. The developers had to admit that values for production lines should be higher, but that is very unusual in product development. Even if this example question is an arguable one, it helped the end users very much to understand their company, CE principles and the rationale behind it. Therefore, the authors deem the usage of the questionnaire in teams moderated by external consultants as crucial if implementation of CE is the main objective.

## Integration and methodology

The main research aspect has been the integration of assessment, solution identification, and tool selection [5]. The integration approach has been confirmed by the end users results, even if some results have not been the best.

*Background:* The integration values can be displayed as a profile. A 6x6 matrix can have values from 0-9 in each point. Assuming that there are only integers, this offers  $10^6$  possible variations. A similarity algorithm compares two different matrices and computes a similarity value between 0% and 100% whereas 100% means, that both matrices are identically.

The developers tested and validated the integration in two ways. On the one hand they repeatedly reviewed the case studies, selected one of these. Based on that case the developers created a hypothetical company assessment and checked if the formerly selected case has been retrieved by the software. This procedure was successful in all cases. Secondly, the developers added real assessment results into the software and checked if the retrieved cases had been relevant to these values.

Within this validation procedure the developers retrieved similarity values between 10% and 68%. Here the developers found out that most cases with a value over 55% are relevant to the former assessment. Sometimes the software could not retrieve any relevant case what was due to the amount of 70 cases in the database that did not cover all potential CE problems. Indeed, if a relevant case has been available, it has been retrieved by the software. Thus, the integration between assessment and solution case identification could be confirmed.

The direct links from the SIM to the TSM are useful, the keyword search as well. The results are sensible to the retrieved study cases and give a broad range of tools and methods that help to solve the identified problem.

## Conclusion

The CEPRA Consulting software system is a prototype that has been validated and confirmed through different tests and pilot applications. Nevertheless, some constraints have to be solved to open the system towards a broad basis of end users and consultants. E.g. the system should be transferred into a more user friendly environment. Since the data (questionnaire, study cases and tools) has been collected by different partners, tighter integration of the modules must be supported if this approach is sustained in future. Furthermore, an electronic payment system has to be integrated to be able to account for special services and information separately. The authors suggest to keep the

methodology behind the software but to rewrite the system using dynamic web pages technology. This would solve compatibility problems and would ensure that most potential customers are able to use the software instantly by usual web browsers. Integration would be easy by sending data from one web page to another using forms.

To meet all users' expectations the CEPRA approach has to be refined to be able on the one hand to provide general CE solutions (working already) but on the other hand to find solutions in a more precise way. Then, the CEPRA system would be able to solve general CE problems on a strategic level and it could solve day-to-day problems providing small but pragmatic CE solutions. So, the CEPRA system would supports companies in introducing Concurrent Engineering, changing their business processes to CE processes as it already does. And it would give a means to the employees by assisting in solving day-to-day problems in a CE environment. ■

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## About the authors:

- René Stach** and **Frithjof Weber** work at the Bremen Institute of Industrial Technology and Applied Work Science.
- Kulwant Pawar** and **Glendon Price** work at the Department of Manufacturing Engineering & Operations Management at the University of Nottingham.
- Bruno Lisanti** works for CEC-Concurrent Engineering Consulting srl, in Rome. [rst@biba.uni-bremen.de](mailto:rst@biba.uni-bremen.de) (R. Stach); [blisanti@ceconsulting.it](mailto:blisanti@ceconsulting.it) (B. Lisanti).

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