Collaborative Improvement as an inspiration for Supply Chain collaboration

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Abstract. The battlefield of competition is today moving from the level of individual firms to the one of the extended enterprises, that is, networks of customers and their suppliers. This paper discusses how learning and continuous improvement today take place in processes based on daily collaboration at inter-company level, i.e. Extended Manufacturing Enterprises (EMEs). The purpose of the paper is to present a preliminary theory on Collaborative Improvement (CoI), i.e. continuous improvement at the EME level. Based on a literature review on Supply Networks, and Continuous Improvement and on evidence from two explorative case studies, the paper proposes a model for Collaborative Improvement in EMEs and discusses a research approach based on Action Research and Action Learning to further develop preliminary theory and actionable knowledge on how to foster and sustain CoI in EMEs.

Keywords: supply networks, continuous improvement, Extend Manufacturing Enterprises, collaborative improvement

Introduction

Continuous Improvement is a consolidated concept in managerial theory and practice, but mainly in the context of stand-alone companies. However, the competitive scenario requires organizational settings based on loose company boundaries and collaborative relations among different units, such as the Extended Manufacturing Enterprises (EMEs). Consequently, the concept of Continuous Improvement should be revisited to understand improvement and learning process that take place also at the inter-company level.
In this paper we present the preliminary results of a three years project (Collaborative Improvement Tools for the Extended Manufacturing Enterprise G1RD - CT2000 - 00299) funded by the EC in the frame of the GROWTH program. The overall purpose of the project is to develop a web based tool and a business model that will support Collaborative Improvement (CoI), i.e. continuous improvement at the EME level.
In this paper we present a model explaining how Collaborative Improvement takes place and may be supported in EMEs. The model at this stage is intended as a preliminary theory to be tested and refined through action research during the next two years of the project.

In particular in the next section, basing on a review of existing literature, we will provide a comprehensive definition of Collaborative Improvement and collocate it in relation to the theories on Continuous Improvement, Supply Chain Management and Networks.
In the third section we will present the methodology selected to develop a theory supporting Collaborative Improvement. Section four presents the managerial issues related to collaborative improvement in two EMEs, an Italian system integrator in the aerospace industry with four suppliers and a Dutch system integrator in the automotive industry with three suppliers. The two EMEs have been analyzed in depth using a common Investigation framework consisting of an analysis protocol and an open questionnaire supporting semi-structured interviews and workshops involving key actors from both system integrators and the suppliers. Based on this evidence we will derive needs and requirements for a business model and a web based tool supporting Collaborative Improvement.
In the fifth section we will propose a model of how Collaborative Improvement takes place and may be fostered in EMEs. The model is intended as a preliminary theory to be tested and refined through action learning and action research. Relevant variables are described and operationalised and their mutual relationships described in a dynamic model. Though still preliminary, results are relevant from both a scientific and a practical level as implications may be derived on how to analyze and foster Collaborative Improvement in the supply chain.

Research background

Supply networks and Extended Manufacturing Enterprises
In recent years most companies have to face a growing complexity of the economic and social environment, owing to a number of factors, including the globalisation of the markets, the sophisticated customer needs and the pace of technological change. One of the answers that has been given to this challenges is outsourcing of an increasing number of processes, not only the less critical ones, but also some core activities that could benefit from external capacity, capabilities or know how (Venkatesan, 1992; Quinn and Hilmer, 1994; Quinn, 1999). As a consequence, firms operate within networks, in which they collaborate with other companies to deliver final products to the market by developing, producing and assembling their parts, components and systems in different units. For this reason, the battlefield of competition is moving from the level of individual firms to the one of the extended enterprises, that is, the networks made by the customers and their suppliers, collaborating to develop, manufacture, assemble and deliver complex, high technology products (Rice and Hoppe, 2001).
The concept of extended enterprise is rooted in the Supply Chain Management stream of the literature. The original focus of this stream was on customer-supplier relationships, widening the horizon of management attention from just the internal aspect of operations to the vertical relationships of the company (Kraljic, 1983).
Recently, a new stream of the literature on customer-supplier relationships observed that the study of the dyadic relation between one customer and one supplier does not allow to capture the overall advantage that could come from an integrated strategy of supply management. This approach suggests instead to focus on the overall set of relationships that form the "supply network" of a focal company (Lamming, 1993; Harland, 1996a). A supply network can be generally defined as a body of advanced relations characterized by an integrated strategy and management policy that the focal company maintains with a limited set of its suppliers (Bartezzaghi and Sassatelli, 2001).
Similarly, the Extended Manufacturing Enterprise-EME (Busby and Fan, 1993; Childe, 1998) is defined in terms of manufacturing companies that co-operate closely to maximize the benefits of the business they are involved in. In this idea the suppliers are viewed as a part of the principal company. Both the concepts of Supply Networks and Extended Manufacturing

Enterprises are based on the notion of collaboration between companies, that is, working together, over an extended period of time, for the benefit of both (Ring and Van de Ven, 1992). The need for these forms of relationship is widely discussed by the literature: a major stream is based on the transaction cost theory (e.g. Coase, 1937; Williamson, 1975; Williamson, 1983; Dyer, 1997), which considers collaboration as the form of relationship that minimize the total cost of the transaction. Collaboration has been widely applied to the relationships between customers and suppliers (e.g. Ellram, 1991; Dyer and Ouchi,1993; Lamming, 1993; Stuart, 1993; Heide, 1995). A particular form of collaboration, referred to as partnership, has been pointed out as the most suitable form of relationship with those companies that supply strategic parts - i.e. parts whose performance influence significantly the quality or cost of the final product, within a complex setting - i.e. a market or a supply chain that is difficult to manage and/or control (Kraljic, 1983). The advantages that could be obtained from partnership are related to costs savings, increased responsiveness, quality and novelty of the products, and often higher flexibility.

One of the consequences of the systemic vision that is associated to both the concepts of Supply Network and Extended Manufacturing Enterprise is that the advantage coming from the collaboration can be measured at the system level, and not only at the company level. The system of the focal company and its suppliers can be viewed as a company with extended boundaries, which sells its products in the market and thus obtains a performance that is related to the product itself (Holmberg, 2000; Brewer and Speh, 2000). All the same, within this setting the performance of each company in the network depends not only on its internal operations, strategies and capabilities, but also on the ones of all the companies that work together and that contribute to the development and production of the final product. Thus, performance should be measured, monitored and improved not only at the single company level, but also at the extended enterprise level.

In particular, improvement is essential for EMEs to adapt to the continuous evolution of the context in which they operate and to sustain or increase their competitive advantage.

The managerial practice shows that both radical and incremental change can be a way to improve supply networks. Radical change means network design or redesign, while incremental change is less drastic, more continuous and can be implemented in a context of stable relationships and collaboration. This paper will focus on the second approach to improvement, since the subject, although highly relevant, has been rather neglected by the literature.

Continuous Improvement

Incremental improvement, essentially in manufacturing, has been widely discussed at the level of single firms by the literature on Continuous Improvement (see e.g. Imai, 1986; Imai, 1997; Bessant and Caffyn, 1997; Bessant et al., 1994; Boer et al., 2000).

The concept of Continuous Improvement (CI) was developed as a new field in Operations and Innovation Management in relation to the Japanese practice of ***Kaizen***. A rich stream of literature bloomed, describing successful applications of ***Kaizen*** in manufacturing processes of Japanese companies. Among the contributors, Imai (1986, 1997) had a very strong influence. According to Imai, ***Kaizen*** is a "low cost common sense approach" characterized by a strong orientation to Processes, People and Standards (Imai, 1997). During the 80s, pushed by evidence of superior competitive advantages obtained in operations by Japanese companies, CI and related concepts (e.g., ***Total Quality Management***, ***Total Productive Maintenance*** and ***Lean Production***) were gradually introduced in the west. Contributions in literature were mainly aimed at describing tools and techniques and their application (Deming, 1986; Juran and Gryna, 1988).

During the 90s a rediscovered attention to the strategic importance of manufacturing and ***operations management*** and a new emphasis on human resources and their diffuse involvement in innovation and change processes contributed to attract management attention

to the strategic and organizational principles of CI. A new stream of literature on CI emerged, characterized by a much higher emphasis on the role of management, setting the strategic, organizational and cultural conditions for the diffusion of CI to the overall workforce. An important contribution in this direction was the one by John Bessant and the CINet research network (Caffyn, 1998). Bessant et al. (1994) summarize the organizational factors which are needed to support continuous improvement; tools and techniques are only one of them, while organizational learning and knowledge management become key issues. CI was redefined as a "company-wide process of focused and continuous incremental innovation" which passes through different stages or maturity levels (Bessant and Caffyn, 1997) thanks to the progressive absorption of behavioral routines. Similarly, another definition describes CI as "*the planned, organized and systematic process of ongoing, incremental and company-wide change of existing practices aimed at improving company performance*" (Boer et al., 2000).
A strong limitation of existing literature on CI is to assume the single company as the unit of analysis. However, as discussed in the previous section, future survival and success of many companies will even more depend in the future on the ability to manage and improve *inter-company* processes. Continuous Improvement, therefore, cannot be confined anymore at the intra-company level. Although this is a core issue for many companies, there is still a substantial lack of empirically grounded contributions and theories on the enablers and barriers to the implementation of CI in an inter-organizational setting. Transferring this concept, originally developed for the context of single firms, requires an adequate analysis and adaptation in order to consider the peculiarities of inter-company processes and organizational mechanisms. This is the specific area to which the research project presented in this paper will address its contribution.

Defining Collaborative Improvement

The analyses of existing literature has highlighted the need to transfer the mechanisms of CI to the enhancement of EME performance, leading to the concept of Collaborative Improvement.
Collaborative Improvement (CoI) may be defined as *"a purposeful inter-company interactive process that focuses on continuous incremental innovation, aimed at enhancing the EME overall operational performance. It is simultaneously concerned with bringing about change in the EMEs, developing EMEs capabilities, and generating actionable knowledge. Finally, it is an evolving systematic change process that is undertaken in a spirit of collaboration and learning"*.
According to this definition, some of the key features of CoI are the following:

- CoI is purposeful and addresses specific issues/needs.
- CoI relies on bottom up continuous and incremental learning efforts, enabled by levers and focused by objectives that come from the top.
- CoI is a continuous, incremental and planned change process aligned with the strategic goals of the EME.
- CoI involves partnership and is based on mutual trust.
- CoI aims at enhancing EMEs performance and developing EMEs capabilities.

Based on this definition, this paper will develop a model to support the analysis and redesign of how collaborative improvement is fostered and sustained within the EMEs.

The two case studies: Aermacchi (It) and Power Packer Europe (NL)

This section presents two case studies: the Aermacchi EME in Italy and the Power Packer Europe EME in the Netherlands. Of both the situation of the system integrator itself and that of its suppliers will be described. The focus is on the relationships among the companies in both EMEs, their current collaboration practices, needs and areas for improvement. We will highlight the similarities and differences between the two EMEs and arrive at requirements for (enabling) collaborative improvement

According to the aims of the paper, the focus is on the relations among the companies in the network, the collaboration practices, the needs and areas for improvement, and the requirements for enabling the collaborative improvement. First we will briefly introduce both EMEs, e.g. first the system integrators are introduced, followed by the suppliers that were included in the case studies.

Aermacchi (It)

Aermacchi S.p.A. is an historical Italian company, operating in the aeronautical industry since 1913. The company employs today 1800 people and in 2000 had a turnover of 236 million Euros, with a growth rate of 20% over the last 2 years. The company is part of a group that embodies also three small companies operating in the same industry.

Aermacchi produces both complete aircrafts (a jet trainer for the military market) and sub-assemblies, within the framework of the world-wide programs of the biggest civil and military consortia. The products for the civil market are grouped in two families: aerostructures and nacelles; while the former are delivered directly to system integrators such as Dornier or Airbus, the latter are sold to engine producers, such as General Electric, Pratt & Whitney and BF Goodrich.

Competition in the aeronautical industry presents some peculiarities, that should be taken into account: in fact, competition takes place between complex networks of companies, the global consortia (mainly Boeing and Airbus), that are designed in the selection phase, and remain stable in the production stage. Another specific characteristic of this industry is that companies can be at the same time customers, competitors or suppliers for each other, thus competition is limited to the bidding phase, while afterwards it leaves place to co-operation. The low volume, high value products, with a very long life cycle, imply that demand is known in advance, allowing Make-To-Order production and long-term planning. Finally, this industry is characterized by very strict quality requirements; consequently, only certified suppliers can be employed and perfect product tracing is needed, making the management of the supply network very complex.

Aermacchi entered only recently in the civil market, that today accounts for more than 50% of the turnover. This market change determined relevant impacts on the strategy of the company, since this environment is highly competitive, not only on the quality of the product, but also on time, reliability and costs.

To succeed the civil market, Aermacchi chooses to focus on its distinctive technologies and capabilities, while outsourcing non-core activities. At the same time, it has developed new competencies, such as composite technologies, supply network management and kaizen practice. As a consequence, the role of purchasing and supply chain management in Aermacchi increased significantly, and the company had to develop its own network of suppliers. The network of Aermacchi's suppliers is now very articulated, ranging from very small, local companies, to world-level players. For some big orders, received by global consortia, sub-suppliers are chosen by the customer itself, thus increasing the width and complexity of the network. Aermacchi classifies its suppliers on the basis of the width of the activities performed, ranging from the suppliers of a small set of operations and workings, to those that deliver a finished part or sub-system. Clearly, the level of collaboration and integration between Aermacchi and the supplier varies much from one type of supplier to the

other. The company has faced only recently the need to develop the relations with its key suppliers, that is, the suppliers of strategic and complex parts. In particular, Aermacchi has been part of the EU project Cascade, whose purpose was to develop solutions for improving the interaction between customer and suppliers [16]. The results of the project in Aermacchi have been: a deeper knowledge of the key suppliers; the adoption of vendor rating system; and the implementation of a web-based tool for sharing information on order status.

4.2 Power Packer Europe (NL)

Power Packer Europe BV (PPE) is an independent subsidiary of the USA-based parent company, Actuant Corporation. PPE employs 425 employees in 80 locations world-wide with a turnover in 1999 of 100 million Euros. The turnover has tripled in 3 years. Power Packer Europe (PPE) is specialised in 'Motion Control'-systems for different markets:

- the automotive: electro-hydraulic actuant systems for operating soft tops or retractable hard tops on convertible cars as well as opening/closing car trunks,
- truck: hydraulic and electro-hydraulic cab tilt systems, cylinders for auxillary steering systems and cylinders for bogle lift systems;
- marine: hydraulic and electro-hydraulic steering systems for pleasure boats, trim/tilt units for outboards, electro-hydraulic operating systems for hatches and masts;
- medical: systems for hydraulic height adjustment of beds, stretchers and tables, electro-hydraulic systems for adjustment of scanner tables;
- agriculture market: cylinders and valve blocks for reversible ploughs, hydraulic non-stop systems and cylinders for adjusting mobile spray and sprinkler systems.

PPE sees itself in a niche market, concerning dominantly automotive and truck. Within Europe there are only 2 main players on both markets of which PPE is one. On a global scale there are a few more players. The competition is known, heavy and mainly on price.

PPE observes a shift towards a commodity market. In this new market the order winning criterion is price, whereas quality and technology are qualifiers. For a company in the automotive industry nowadays it is a main challenge to constantly monitor the cost-structure in order to remain profitable as a result of the price pressure from the OEM's, the increase of prices of raw materials and the contracts on long-term delivery schedules.

PPE has as a strategic objective to product zero-defect products against the lowest total cost from world class suppliers to satisfy PPE requirements on quality, cost and delivery. To realise this strategic objective PPE selects (1) suppliers that apply for Continuous Improvement, (2) suppliers that are able to realise early supplier involvement starting from the first conceptual phase to guarantee a maximum use of the supplier's knowledge, which increases efficiency and reduces the time to market and cost, (3) suppliers that comply with world class standards. The supplier base of PPE is international, ranging from small local companies to more world-level players. Continuous improvement and continuous cost reduction are an integrated part of PPE's policy. Continuous benchmarking is used to compare suppliers against the best in class. Cost analyses with suppliers are based on open book calculations in order to achieve targets. PPE aims for close co-operation and long term agreements with a limited number of suppliers. As such, PPE looks for long term, highly involved and dedicated partners that fully support the company in assembling and delivering systems of top quality at agreed competitive prices at the promised delivery date to customers. All suppliers are assessed on the areas of Quality, Cost and Delivery. In order to be selected as a supplier, a certain score on all three areas is required. The assessment is carried out conform the procedures/ principles in QS9000. A topic that is also being taken into account is whether the potential supplier can be involved in the early NPD process and can add knowledge that is not available within PPE. The assessment results are subject of discussion in the Management Team of PPE (both the assessment results and publication/announcement). This way the entire organisation is informed on the decision on the supplier and information is transparent.

Suppliers

The suppliers selected by both system integrators to be involved in the project represent different types of relationships with the system integrator. This choice was made to understand the different implications of Collaborative Improvement in each case. The relationship is assumed to be determined by both structural characteristics of the company, such as size, location, competence, dependence of each other, and the object of the interaction, that could be the supply of finished parts or just the outsourcing of some activities. As mentioned before, the cases have been chosen to represent as much variety as possible.

The selected suppliers are presented in table 1 (they are numbered and not mentioned by their full company name).

Table 1: suppliers involved in the case studies.

Aermacchi	***Power Packer Europe***
1. A medium company supplying a sub-assembly (a fuselage of a commuter aircraft), that has been chosen because of its close relationship with Aermacchi, aimed at the progressive transfer of operations from the customer to the supplier,.	1. A small/medium sized company, supplying parts for the pump for opening the roof and tilting the cabin of a truck. This company was chosen because of its long term relationship with PPE and its collaboration on improvement projects.
2. A small company, that supplies critical workings (complex metalworking)mainly in a subcontracting setting; this company was chosen because of the quite intense collaboration oriented towards improving products and processes	2. A medium sized company that is specialised in the production and development of cylinder-tubes for the automotive industry and that is able to handle the entire process from buying the raw materials to delivery of cylinder-tubes. This supplier was chosen because of its fairly young supplier relationship with PPE.
3. A very small, historical subcontractor that manufactures prototypes and special parts in small/medium series through CNC and non-conventional machining, chosen because of its need for support and development as a consequence of the evolution of the competitive environment	3. A large company supplying delivers plastics molding products to PPE, that was chosen because of its intensive collaboration with PPE for a number of years now.
4. A large supplier of composite components, that is at the same time competitor on some of the programs of the global consortia; this company was chosen because of this twofold role and the higher involvement of bilateral knowledge transfer that characterizes the relation between the two companies.	

Given the exploratory nature of the research, a case study methodology (Yin, 1984) was selected, which is coherent with the aims and context of the research, since Collaborative

Improvement is a rather new topic and research in this area, it is required to first of all explore the existing practice and to build new theory (Eisenhardt, 1989).
The interviews have been performed using an Investigation Framework, that defined the research objectives, assumptions and hypothesis that guided the empirical research, an analysis protocol and the structure of a standard interview. Although the protocol suggested open interviews, a list of possible questions was developed, in order to facilitate the homogeneity of the interviews between the different interviewers investigating the EME in the different countries.
The interviews addressed, initially, general information on the company, in order to understand its characteristics, scope and goal of collaboration between the firms within the EME The second phase covered the issue of CoI, asking about examples of past collaborations and inquiring about enablers and disablers for CoI. Finally the requirements were investigated, both in terms of organizational needs and software support.
The interviews in the system integrator were extensive with employees from different functions, namely procurement, engineering, production, quality and IT systems. The focus of the analysis was the relationship with the suppliers, trying to understand its evolution over time and the attempts to collaborate for improving performance, both in successful and not successful cases. Subsequently each supplier was interviewed at his own site, to catch his own opinion on the relationship with the customer, without being influenced. Finally, the findings were presented to all the companies together in a workshop, in order to consolidate the results.
The findings of these exploratory case studies were validated both in Italy and the Netherlands. In Italy, six other companies operating in different EMEs have been interviewed, in the Netherlands three other companies were interviewed and the results of the case studies were discussed with two more companies. In the other partner countries, case studies were performed by academic partners to analyze the other EMEs that are part of the project and additional companies were interviewed to extend the number of companies in the sample.

Collaborative improvement: the current situation, areas of application and requirements for CoI

According to the aims of the study, the case studies were carried out in order to (1) understand the current situation with regard to collaboration and improvement activities, (2) areas for possible implementation of Collaborative Improvement and (3) the requirements by the companies, in terms of organizational and technological tools. Companies were asked to report past histories of successful or unsuccessful collaboration activities aimed at performance improvement. In addition, companies were asked, according to their experience, to point out the areas that could benefit from the introduction of CoI practices, the opportunities they could see from the implementation of CoI and the organizational and technological requirements to support it. The analysis of the case study highlighted also some barriers to the implementation of Collaborative Improvement. All these results are discussed in the next sections.

The current situation with regard to collaboration and improvement activities

As already pointed out the suppliers that were selected to be involved in the case study, represent different types of relationships with the system integrator. Tables 2 and 3 include a short description of each of the current relationships.

Table 2 CoI relationship of Aermacchi and its suppliers

	Aermacchi suppliers
1	Initially the relationship was a traditional (logistical) customer-supplier relationship with strong collaboration on process technology issues and competence transfer. Quality problems were solved through improvement projects transferring knowledge that was not formalized in technical documents. The next step in the collaboration and improvement process will be the transfer of the full responsibility of the supply to the supplier, including the purchasing of parts and components. The relationship is recent, but very intense, since both sides invest great efforts: for the supplier this is a relevant chance for improvement, for the system integrator this is free capacity for what is to become core activity, i.e. assembling entire systems.
2	The relationship is strong, stable and strategic. Interaction is supported both by formal information exchange and informal communication channels, developed by a number of people who have previously worked for Aermacchi. Personal contact is seen as the key for a successful interaction. Improvements take place merely on an ad-hoc basis and there is a need to establish clear communication channels in order to make personal contacts more systematic.
3	There is a very close relationship that evolves around fast prototyping and urgent deliveries, mainly for old programs, prototypes and tools. The intention is to further develop the relationships and new collaboration activities on a more structural basis.
4	The relationship is a perculiar one, since the supplier nowadays not only is a supplier, but also a competitor for specific deliveries. Nevertheless the relationship is such that it allows to learn from each other and collaborate on product improvements on a project basis.

Table 3 CoI relationship of Power Packer and its suppliers

	PPE suppliers
1	The relationship resembles that of a traditional supplier-customer relationship, where problems in delivery are the inducement to start an improvement project. Power Packer is the initiator . Faults, problems, etc trigger the need for improvement and therefore CI is much more reactive than pro-active. The intention is to increase collaboration and work towards early supplier involvement.
2	The relationship is yet young and currently there is no track record of CoI activities between the companies. Both however are very interested in long term, structural CoI according to a specific improvement system and format.
3	There is a close relationship, including elements of early supplier involvement. The trigger for CoI activities is balanced between the two companies, and organised through improvement projects. Face-to-face contact is used for sharing information in improvement actitivities.

As can be seen there are quite different levels and forms of collaboration and structures for organising and carrying out improvement activities. A preliminary finding studying the improvement relationship between system integrators and suppliers is that basically three maturity levels can be identified:

1. Company based improvement relationship: the level of involvement of the two companies is limited to the sales versus procurement function, the relationship varies with market developments, communication is price based, there is no benefit sharing logic and improvement is aimed at company level performance improvement.
2. Co-operative improvement relationship: the level of involvement is enlarged to different functional managers (including manufacturing managers, engineers and quality

managers), the relationship is long term, though asymmetric, communication is rich but filtered through hierarchy and benefit sharing is dominated by bargaining power. Nevertheless, improvements are aimed at the dyadic level.

3. Collaborative improvement relationship: involvement of the companies is diffused. There are different (cross-)functional horizontal links. There is a long term partnership on an equal basis with regard to improvement activities and communication is rich and horizontal. The benefit sharing logic can be characterised as long term holistic whereby the driver of the improvements is the sustained competitiveness of the EME.

In general it can be observed that improvement activities merely develop in dyadic relationships between supplier and system integrator and not yet on an EME level. The majority of the relationships in the case studies are on the first and second level. The third level is recognised and the companies in the CO-IMPROVE project have stated that there aim is to develop level three relationships.

The findings from the case studies also indicate that the activities frequently have the character of improvement projects and not that of collaborative, structural and pro-active improvement relationships. The initiative in general is taken by the system integrator and is driven by problems with regard to quality, cost or delivery. We can see that, while the generation of improvements can, and should, be continuous (according to theory), it is rooted in day-to-day practice. Improvement activities are centered around product and process problems. Industry characteristics are also of importance. In particular, this is relevant for the aeronautical industry, due to the strict dependence on certification and authorization for changes in products and processes. In the automotive industry changes are merely initiated because of cost saving considerations, but also certification and authorisation issues are increasingly important.

The analysis of the case studies highlighted opportunities for CoI at two different levels. The first level concerns collaboration on an operational level (c.q. collaborative operations), where performance is measured in terms of time, quality and cost. The second level refers to a number of processes that are concerned with relationship management, that is, strategic, long term activities oriented to the development and management of inter-company relations, that support operational practice and, consequently, have a direct impact on operational performance.

As far as collaborative operations are concerned, from the case studies five specific improvement areas have been identified:

- goal sharing and mutual understanding;
- order management;
- quality management;
- manufacturing;
- change order management.

The interdependencies between these areas are shown in figure 2.

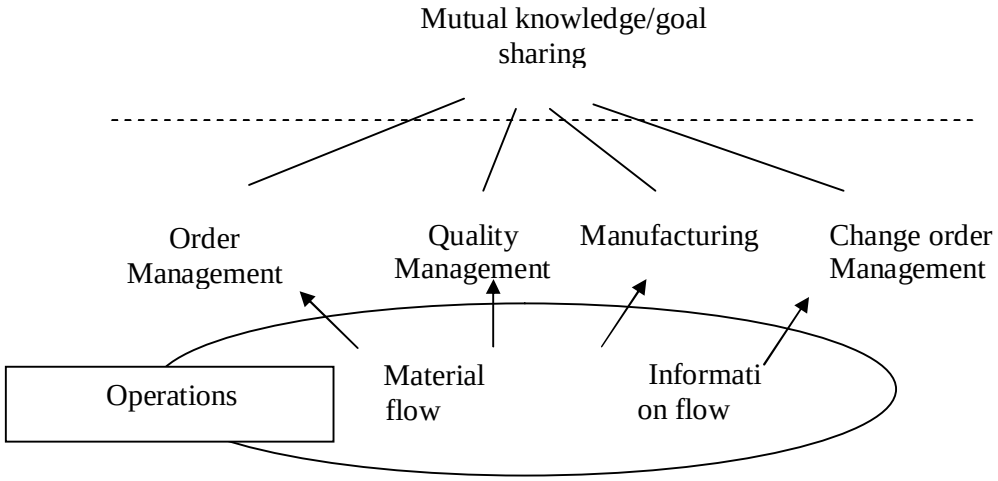

Figure 2. Five improvement areas of collaborative operations

The opportunity to improve the *manufacturing* process derives from the improvement suggestions that suppliers propose to improve products and processes, both for cost reduction and for quality improvement. These suggestions generally require joint evaluation and development activities, and thus (could) benefit from CoI activities. An example of collaboration aimed at cost reduction was given by one of Aermacchi's suppliers (nr. 4), who developed a proposal for changes in the manufacturing process, aimed at reducing the cost of the part that was supplied. Although changes were feasible and effective, the improvement suggestion was not implemented, because a new certificate was required. Another example of product improvement and cost reduction was, that a supplier (nr. 3) PPE redesigned a gearwheel in order to reduce parts, reduce costs and reduce assembly time. The final design and final product did meet requirements and functionalities and still was cheaper compared to the former gearwheel. PPE was able to lower the cost while enhancing the required quality.

In summary, the opportunities to use CoI in the manufacturing process refer to the possibility to jointly improve product or process design to obtain cost savings, quality improvement or increased reliability for the overall EME. This area is particularly relevant when product components are characterized by high interdependency, thus requiring co-ordination along the supply chain to implement changes.

The second area for Collaborative Improvement is *quality management*. The case studies highlighted that collaboration could improve the definition of quality control plans for free-pass and the measurement and follow-up of quality performance, in order to focus on problems and react promptly. An example can be found in the relationship between PPE and supplier 1. It was found out that during assembly an inner circle of a rotor became eccentric. To solve this problem a project team was installed that searched for the cause of the problem. The team worked according to a problem solving technique, so causes were clustered, solutions were identified and clustered and people started working on the most important problems.

The case studies emphasised that in general, collaborative tools and practices that help companies to joint evaluate quality problems, to monitor and follow-up quality performance, to define clearly roles and responsibilities, could support realizing relevant improvements in quality management.

A third improvement area is *order cycle management*, since the performance on this process highly depends on the integration of all the activities needed to fulfill the orders, that are performed across the company's boundaries. The improvement of this performance often requires collaboration trough e.g. a rich and timely share of information on order status, demand forecasts, administrative and technical issues. For example supplier nr. 2 relies heavily on personal contacts with Aermacchi to improve information exchange in order to manage order advancement, delays, technical problems, etc. Tools supporting a more formal and structured way of working can give great advantage.
The fourth area that emerged from the case studies is *change order management.* A timely exchange of relevant information on design changes and related order update could greatly improve the effectiveness and efficiency of operations, especially when changes concern a complex supply network. Supplier nr. 4 of Aermacchi for example, suffers from late communication of change orders, such as delivery quantities, a problem that is due to late information by the final customer, thus preventing the determination of problems upstream in time. Effective change order management at EME level could benefit from CoI activities such as co-ordination between partners and a fast and complete information exchange.

The areas of interest per supplier is indicated in figure 3.

	PPE			**Aermacchi**			
	Supplier 1	Supplier 2	Supplier 3	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Collaborative operations:							
• Manufacturing	X	X	X	X		X	X
• Order management	X	X			X	X	X
• Change order management			X		X		
• Quality management	X		X	X			X
Relationship management:							
• Goal sharing & mutual understanding	X	X	X	X	X	X	

Figure 3: areas of interest per supplier

The requirements for Collaborative Improvement

Enablers for successful CoI
The information that was gathered in the case studies on the current situation with regard to collaboration and improvement, experiences in improvement activities and future developments, enabling factors for successful CoI on an EME level could be identified:

1. The first enabling factor is *goal sharing along the supply chain*. This is required in order to allow actual collaboration and to finalise efforts to effective results, with benefits perceived by all the actors. Potential improvements don't take place because of misalignment of objectives and priorities between customer and supplier (and end customer).
2. Although the CO-IMPROVE project is deliberately focussed on EMEs that pursue prosperity through collaboration, consensus and synergy, at the end of the day there is always partner interest in terms of burdens and goods that have to be shared and agreed upon. Therefore it is required to consider political processes. *Trust and long-term*

perspectives play an important role in these processes because the contemporary agreements may not be balanced with respect to short term benefits for the partners, but for the long term they should be.

3. *Both organisational improvement and ICT support are needed*. The former is required to enable the exploitation of the improvement potentiality hidden inside collaborative relationships, while the latter both increases this potential and enables activities that otherwise would be very difficult, such as distance interaction and knowledge management.
4. The last factor identified is *openness*. Not only openness in sharing information to the suppliers, but also readiness to discuss problems and faults with each other in order to generate greater benefits for the entire EME. However the openness is restricted by characteristics of the industries that both EMEs are in, e.g. the aeronautical and automotive industry. These restrictions and ways of coping with it are essential for the collaborative improvement process.

Organizational Needs

The case studies highlighted the need for organizational settings that are strongly coordinated, within the company and with other partners, supporting intensive information exchanges and the development of strong interactions between the actors involved. The first requirement is an orientation to inter-company processes, both within and between companies. This means integrating activities, streamlining processes and increasing information flows along the processes at the inter-company level, attributing clear responsibilities to catalyse the attention of the people involved. The second requirement for enabling CoI is an enforcement of communication, thus allowing a rich and timely information exchange, and the implementation of a knowledge management system, which could prevent the loss of competencies and experience due to changes in the network configuration. The third requirement, finally, is the development of the suppliers. In fact, especially the smaller suppliers need support for the acquisition of new managerial and technological capabilities, in order to better contribute to the generation of improvement.

The specific organisational needs within the above mentioned requirements are the following:

- goal sharing and alignment;
- integration of activities both within and between companies;
- definition of interfaces between companies;
- definition of process owners at inter-company level;
- joint decision making between customer and supplier;
- enrichment of communication;
- knowledge management;
- supplier development support.

ICT support

The ICT requirements that emerged from the case studies express the needs of the companies for a support of inter-company operations, especially those requiring information exchange and distance interaction, in order to overcome traditional problems, such as geographical distance and timeliness and quality of information exchanged. The first requirement is the integration of ICT tools in the specific company processes and existing systems, since there is a need for both customisation and interconnection with different standard platforms. The second requirement is the support for rich information and knowledge sharing, to support both communication enrichment and knowledge management. Third, there’s a need for proactively managing the workflow of the inter-company processes, with a push system that assigns tasks and informs the process owner when problems arise. Last, functionalities for distance, on line interaction is needed, to facilitate generation of ideas and problem solving.

A list of the specific requirements for ICT tools needed includes:

- customization;
- integration with existing systems and standards;
- support to information sharing;
- support to knowledge management;
- workflow management;
- alert system;
- communities of practice;
- on line interaction.

Barriers to Implementation

The case studies also highlighted barriers to the introduction of collaborative improvement that should be taken into account in CoI, since they can affect the implementation, operation and support of collaborative improvement.

The first group of barriers to collaborative improvement are linked to the dyadic relationships between the companies within the EME. Many relationships are still more market oriented than true partnership relations. Lack of trust and the heritage of old attitudes within the companies are barriers towards collaborative improvement within the EME, where collaboration is not yet a habit. Besides, the different interests and politics within the EME and the culture of local and short-term optimisation instead of understanding the potential benefits of collaboration at EME level are also hindering collaboration.

The second group of barriers are related to network specific characteristics. In particular, the aeronautical industry is characterized by very strict quality and safety requirements that imply the need for a complex certification system that limits the potential improvements in product and processes. Also the strong concern with security limits possibilities within the automotive and aeronautical industry to share information.

Specific barriers to implementation of CoI as identified in the case studies are the following:

- lack of resources in terms of time, money, people etc.
- traditional market relationships;
- lack of trust;
- heritage of old attitudes in companies;
- unsupportive culture;
- problems of internal communication and internal barriers;
- very strict quality and safety requirements;
- complexity of networks;
- variety of standards of communication and of organisational procedures;
- strong concern with security;
- different interests and politics;
- lack of priorities.

A Model of Collaborative Improvement

Starting from the requirements identified from in-depth case studies the co-improve project aims at developing a model supporting the analysis and redesign of how collaborative improvement is fostered and sustained within the companies.

In more detail the model will support the EME in:

- Understanding and describing the process of Collaborative Improvement that takes place with each of the key suppliers;
- Assessing the current level of integration in the operational process and the level to which Collaborative Improvement takes place and is supported in the EME;

- Assessing the current level of performance and the need for improvement;
- Redesigning, according to the EME's priority and contingent situation:
    - the configuration of enablers to put in place;
    - the collaborative improvement process to foster;
    - the functionalities to implement on a web-based support system

Coherently with the Action Research approach, a preliminary model has been developed to be tested and refined in Action with the EMEs involved in the project. The model, that is based on state of the art theories and customer requirements described in the previous sections, describes the relevant variables of the Collaborative Improvement process and the basic hypotheses about their dynamic relations.

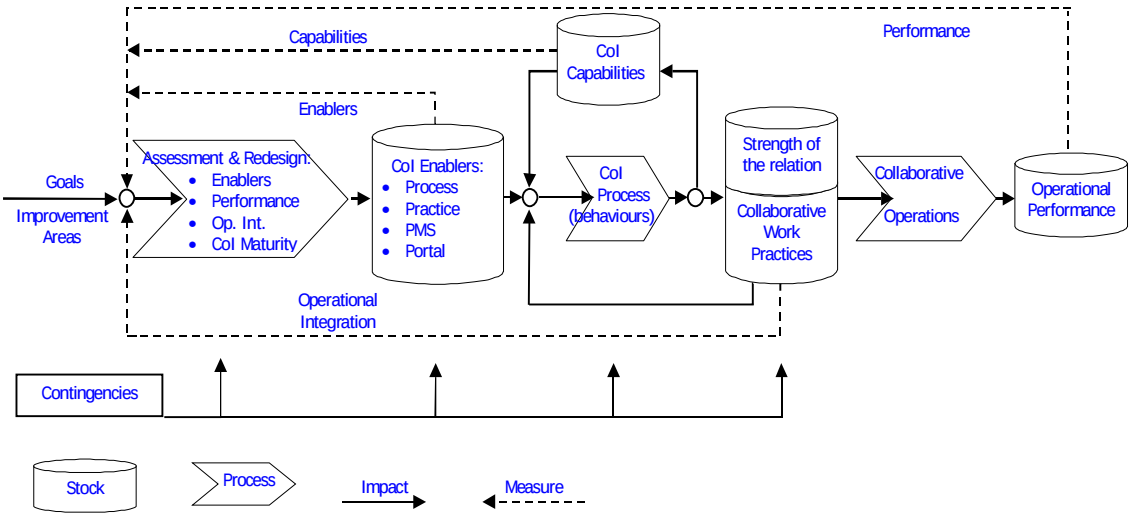

Fig.1: Dynamic model of Collaborative Improvement

The key variables identified are:

- *Collaborative Improvement Capabilities*: measure the potential of an EME to perform Collaborative Improvement. They are set of consolidated behaviours and shared values concerning improvement and collaboration.
- *Collaborative Improvement Behaviours*: the way people and groups in the EME act and interact in terms of Collaborative Improvement;
- *Collaborative Improvement Enablers:* levers that the company adopts to stimulate CoI behaviours.
- *Collaborative Improvement Performance:* effects of the CoI activities, measured in terms of change in the Operational Performance at EME level.
- *Contingencies*: external variables that are likely to have a relevant impact on the EME's CoI approach and its effectiveness.
- *CoI Enablers;*
- *CoI Performance;*
- *CoI Maturity level(assessed in terms of CoI Capabilities);*
- *Operational Integration (assessed in terms of degree of integration in the Collaborative Work Practices and Strength of the relation);*

Given the result of the assessment and the Goals and Improvement areas, enablers are redesigned to foster behaviours that allow the generation of the improvements needed to

achieve the desired goals. The proposed redesign methodology guides the EME in redesigning configuration of CoI enablers in terms of:

- *Process definition*: actors to be involved, activities and information flows;
- *Practices*: methodologies and organisational, managerial and technological tools to implement in order to foster CoI;
- *Performance measurement system*: goal setting, performance measurement and benefits sharing to be adopted;
- *Portal functionalities*: services and functionalities to be implemented on the web based platform.

The effect of the enablers on the desired CoI behaviours also depends on the current level of CoI maturity (CoI Capabilities) and of Operational Integration (Collaborative Work Practice and Strength of the relation).
The behaviours give place to the CoI Process, which is a cycle of:

- Goal alignment
- Improvement generation
- Improvement implementation
- Improvement evaluation

Going through these learning cycles, the EME over time improves collaborative work practices and strengthens the relationship, creating trust and mutual openness. Collaborative Operations become therefore more effective, thus improving performance at EME level. At the same time the iteration of the CoI Process consolidates behaviours, thus allowing the acquisition of CoI Capabilities.
The block at the bottom of the figure reminds that contingencies affect CoI and should be taken into account; the current advancement of the research allows only to formulate preliminary hypothesis on the effect of contingencies, which will be tested on the field through Action Research cycles. In the same way, also the relationship between the level of Operational Integration and the CoI maturity level has not been completely understood yet, but research hypothesis have been formulated:

- The level of Operational Integration that better suits each specific EME depends on the contingencies.
- Adequate enablers should be implemented to foster the realignment of Operational Integration to the contingent setting, and to maintain the alignment over time.
- A certain CoI maturity level is needed to realign Operational Integration and it depends on the cost/benefit ratio. The main drivers of the benefits that could be obtained are the strategic importance of the good exchanged and the improvement goals, which in turn depends also on the gap between the current Operational Integration level and the desired one. The costs depend on the chosen enablers, on the current Operational Integration level and on the contingencies. In this way the optimal CoI maturity level is defined; however, contingencies and the current level of Operational Integration are expected also to bound or limit the possibility to achieve the desired CoI maturity level. In particular, high levels of CoI maturity are supposed to be not feasible with low Operational Integration levels.

Managerial implications and future research

Continuous Improvement is a consolidated concept in both managerial literature and practice; the benefits of its implementation have been extensively recognised in the areas of operations as well as innovation. However literature has focused on single companies, considering CI a company-based approach. However, in many industries competition has moved from the individual company level to the Extended Manufacturing Enterprises, due to increased

importance of outsourcing and collaboration within networks. In this context, the performance of the single companies within an EME strongly depends on the overall performance of the EME. Thus, in order to sustain and develop the competitiveness of companies in an EME context, specific approaches should be developed aimed at identifying, supporting and constantly increasing the benefits of collaborative relationships. Collaborative improvement, that is, the transfer of CI to the EME level can be considered an inspiration for these needs.
The empirical data gathered through the case-studies indicate that although different dyadic improvement relationships can be distinguished between system integrators and their suppliers, in general these relationships are problem-driven and are either on the level of company based improvement or co-operative improvement, but have not yet developed into collaborative improvement activities. The case studies and the following workshop(s) have helped starting a discussion between system integrator and suppliers on current relationships, collaborative practices, experiences, expectations and common future goals and strategies. This discussion now is to be supported by tools that help develop CoI, such as a business model and software tool.
The empirical evidence in this paper allows us to draw some preliminary conclusions on CoI and develop preliminary theory on CoI through the development of the business model that is to be tested in practice.
This Business Model recognises collaborative operations, collaborative improvement and collaborative learning activities that each can be measured in terms of specific changes, it describes different variables that are of importance in building CoI and their dynamic relationship.
This business model is to be developed into a software tool that will be implemented in the EME, facilitated by a so-called Action Learning (AL) and Action Research (AR) approach (see Coughlan and Coghlan, 2002).

Action Learning	**Action Research**
• Participants work on real organisational problems that do not appear to have clear solutions. • Participants meet on equal terms to report to one another and to discuss their problem and progress. • Give managers scope to learn for themselves in the company of others. • Encourage teachers and researchers in management to help others to learn with and from each other.	• Focuses on research <u>in</u> action, rather than research <u>about</u> action. • Is a cyclical process of planning, taking action , evaluating the action, and leading to further planning and so on. • Members of the system, which is being studied, participate actively in the cyclical process. • Is both a sequence of events and an approach to problem solving.

Action learning can be considered to be a methodology of a change strategy whereas action research involves a research methodology.
This AR/AL phase of the research will start 1st of May 2002. For the EMEs this implies customising the business model to specific circumstances, practices and requirements. For the researchers this implies formulating the hypotheses will be tested through the action research. These hypotheses are (1) underlying the business model and (2) underlying the choice of research strategy. A number of areas for hypotheses can be listed:
- the process of CoI in EMEs;
- detailing and customising the business model and software on an EME level;
- the use of IT for (collaborative) improvement activities;
- performance improvement as a result of CoI;
- the role of contingencies in implementing CoI and software to support CoI;

- the usefulness and usability of action research as a research strategy for this type of research and problem.

The implementation process of both the business model and software in the respective EMEs, as well as the final "product" of the implementation are dependent on contingencies of the peculiar situation within each EME. Some already mentioned contingencies are the type of industry, the type of supply, type and maturity of relationship between supplier and system integrator. Other contingent variables require further exploration and definition in future research. Clearly all these considerations are only a first step to building new theory , that is to be further developed and tested in different settings.

The future research will address all these topics through an action learning approach that will allow both the empirical testing of the hypothesis and refinement of the business model and software through an iteration of cycles of applied research, directly in the field, and theory building on the base of empirical findings during the action research.

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