# Collaborative Clusters: A Customer Focused Innovative Approach for Product Development

C. Ucler, O Vayvay

***Abstract* —Recent developments in the competitive global environment have been forcing the Original Equipment Manufacturers (OEMs) and the supplier segment in the V-Cycle of product development to find creative solutions of cooperation by eliminating time- and resource-waste of competition against each other. These work mainframes the way to integrated product development by building up collaborative clusters (CC).**

***Index Terms* — Cluster, Collaboration, Concurrent Engineering, Integrated Product Development.**

## I. Introduction

The globalization has resulted in such a market pressure, that companies have to reduce their product cycle times as much as possible to remain competitive. This has resulted in different aspects such as reducing the engineering time, the production time or the time for logistics.

However, the requirements of the customers are not getting less then before. There is always a need of products with a higher performance than before, where security, quality and durability have to be also assured. Moreover the time-to-market has to be minimized, but the environmental limitations have to be retained. Finally the aesthetical aspects have to be considered and the end product shouldn't cost too much.

This situation leads to a conflict: On the one hand there is an immense pressure coming up from the customer site, on the other hand companies have to survive against their competitors. This leads the way to different cooperation models and mechanisms among companies. In [16] Su et al are underlining the product innovation, linking technological competence such as engineering and process know-how with knowledge about the customer.

Consequently, the rising trend of "focusing more on core competencies, accelerating outsourcing trends, increasing industry-wide collaboration and embracing more "best value" providers from outside the industry, thereby providing truly end-to-end customer solutions" [1] can be observed. In [8], the company of the future is described as the derivation from assemble of teams of employees, focused on specific activities, collaborating across organizational boundaries inside and even outside the company, replacing the static hierarchical organization. In addition, shortening time-to-market and mass customization are becoming the major trend in the consumer-oriented market [10].

Therefore the so called clusters can be seen in many fields, especially in automotive sector, where companies are brought-up together. Such clusters are built to have a higher competitive level by collective sources.

E.g. the West Midlands automotive cluster reflects these challenges, particularly the trends of globalization and consolidation [12]. Nevertheless such as in most existing clusters, also here is the knowledge kept by the OEMs and mostly the engineered drawings are precisely defined and in the end effect it is only the procurement of a part or sub-assembly to be built in, thus currently in this approach there is no real collaboration in terms of engineering. Such groupings are moreover a collective of companies, where the appropriate capacities for production are used in order to create a virtual marketplace, resulting on not more than a business-to-business environment.

The main challenge is to involve cluster members also in product life cycle phases, where specific know-how is needed [9], resulting in collaborative engineering. Thus the real driving force is the capability of knowledge transfer and long term partnership, enabling the outsourcing of engineering work in a concurrent and collaborative environment. The importance of knowledge management and customer focus in the innovation of product technology has been recognized [16]. Nevertheless all models are based on competition and mostly in smaller companies many resources are wasted just to beat the competitor, leading sometimes to the bankruptcy. This fact points out the most critical area of innovation: the cooperation of several companies as a living organization, not competing, but completing each other by interacting with the customer, which is covering all four innovation types; product, process, marketing and organizational innovation due to the Oslo Manual [also see chapter 3 of 17].

In [10] the definition of the collaboration is made as the possibility of different staffs, being able to work jointly work on the same project without being obstructed due to their physical locations. Consequently the focal point of this paper is to introduce a system of cooperation in CCs, constituted of diverse companies, working together.

## II. Customer-Centric Product Development

The stages of the New Product Development (NPD) process include the generation of new product ideas, the development of an initial product concept, an assessment of its business

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attractiveness, the actual development of the product, testing it within the market, and the actual launch of the product in the marketplace [2]. Hence everything starts with the customer and ends on the customer side. Moreover the long time survival of most companies is considered to meet the customers' expectations [3]. But just buying parts from other companies in order to assemble them to the end product, decouples the suppliers from the customer requirements. Consequently the suppliers produce something where they do not know what fore and they cannot create their added value, which is a big mistake. In opposite, successful NPD has to have the customer as the focal point. Thus the Customer to Customer (CTC) model, using the concurrent engineering (CE) principles is proposed (see fig. 1), covering all different phases of the PD cycle, which will be explained next.

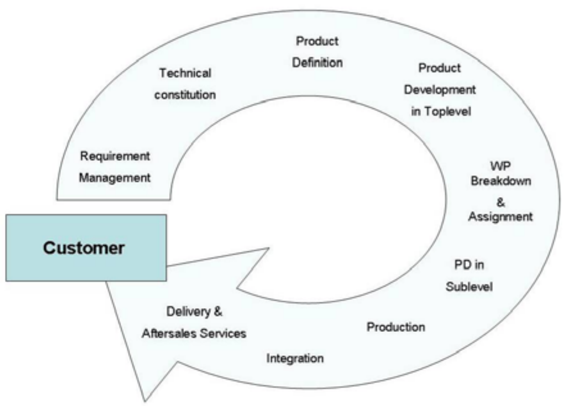


Fig. 1: From Customer to Customer (CTC) model

Once the requirement management and the resulting technical constitution are used by the OEM to define the product, the product development in the top-level can be accomplished by the OEM. This includes only the macro level and the detail development is carried out later on, when the Work Package (WP) breakdown and the assignment to different divisions in the company is accomplished.

Different tasks after WP breakdown can be assigned to individual divisions or smaller work groups of those, where different tasks can be done simultaneously, using CE. Since CE will include all the teams of other groups, like production and marketing, closed loops due to problems in the design cycles will be minimized. Similar to CE, the integrated product development (IPD) is a systematic approach to product development that deals with all aspects relevant for the design of a new product, such as function, form, use, production, sales, economics and sustainability to fulfill the customer requirements by including strategy, organization, business process, techniques and tools. Most of the CAE and Management Information System (MIS) tools are embedded into the IT infrastructure of the IPD environment. CE enables the usage of such tools simultaneously, providing a higher synergy level. Thus the usage of IPD and CE is an important aspect for adopting CCs.

The benefits of CE and IPD used are including, but not limited to 30% to 70% less development time, 65% to 90% fewer engineering changes, 20% to 90% less time to market, 200% to 600% higher quality, and 20% to 110% higher white collar productivity [5]. In order to maximize the benefits of CE, the 3D CE approach of [6] is to be used including also supply chain in addition to production planning and product design [6]. Unlike sequential design, IPD and CE bring different functional departments together and as a step further the computer supported cooperative/collaborative work (CSCW) is proposed in [p.48 of 13], underlining the need of a system based on IT for CCs making use of CE and IPD.

Once the development work is finished using CE, the production and consequently the integration work is carried out also supported by CE. Different methodologies including the cellular manufacturing and responsibility network approach are discussed for the collaborative manufacturing networks therefore [p86 of 15] and can be adopted in the CCs. Finally the delivery to the customer and the after sales services until the disposal are ending the cycle. In other words everything starts from the customer and it also ends in the customer, resulting in a customer-centric PD.

Nevertheless, using all these systematic, the rise in speed is mostly not sufficient enough, since the market is asking for more customized products and the resources within a company is limited. E.g. within the "EU 5-Day Car Initiative" is dealing with a radical leap for the European automotive industry from the stock push and mass production thinking of the last century, to a stockless build-to-order (BTO) production strategy. Processes, resources and structures need to be completely flexible to switch from one model to another to react on fluctuating demand [4]. Thus there is a market force to the OEMs to empower scalable and flexible teams, which is only possible by using a network for outsourcing.

Today outsourcing is widely used in Aerospace and Defense sector. Therefore the V-Cycle is used, defined in most of the systems engineering handbooks. As given in figure 2, the V-Cycle of PD starts by the design process, fallowed by the realization and the integration.

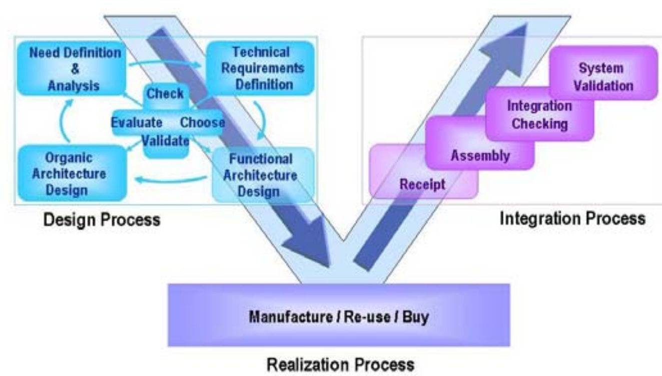


Fig. 2: V-Cycle, based on [7]

In general we can define a pyramid in the product development as shown in fig. 3. This is similar to the concept of automotive supply chain, which consists due to [10] mostly of 3 tiers. The only difference is that due to the CTC model the customer is set to the top of the pyramid. In the second level the main integrator, the OEM is set and below this the level of subcontractors for sub systems is defined. On the lowest level is the pool of suppliers for products, which are mostly dealt as a commodity. If the pyramid is set together with the V-Cycle all levels is getting along together

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spanning the network for clustering.

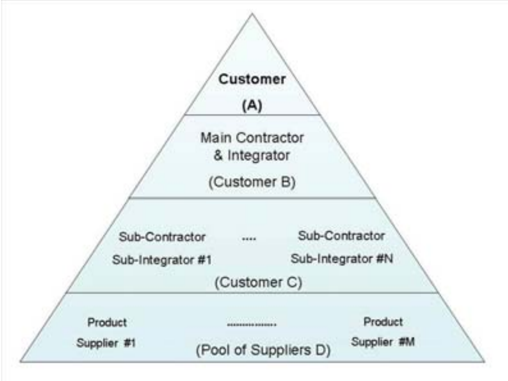


Fig. 3: The Pyramid of PD

## III. Proposed Model for Clustering

### *A. Cluster Constitution*

In [9], Ratti and Gusmeroli have investigated Professional Virtual Communities (PVC) inside the ECOLEAD project and they have determined three dimensions that are at the basis of the human realization: Knowledge, Business and Social & Ethics. Moreover they have identified collaboration technologies as critical, which are coming from portals, groupware and personal information management (PIM).

Since collaboration shouldn't be depending on the voluntary participation of the associates, an IT framework has to be created in order to manage the whole process, including but not limited to cluster, project and knowledge management by providing all necessary means for information exchange.

Due to [9] the currently existing technologies cover three main categories:

1. Collaboration tools: emails, instant messaging, Audio, video, and web conferencing, RSS, wiki, blog.
2. Personal information management and groupware: calendars, email, address book, task list, groupware (e.g. eGroupware, OpenGroupware, IBM Lotus Notes, BSCW, MS Sharepoint, etc.).
3. Portal technology: SAP, IBM, SUN, VE-Forum, etc. [9]

Nowadays these tools are mostly dispersed and there is no common platform for all of the companies. On the top of this there are many PD specific tools, such as CAD, CAM and CAE and a collaborative environment integrating diverse information systems by either defining common interfaces or by fixing the software being used. Due to [11] this can enable the creation of virtual enterprises with competencies to effectively and efficiently share their knowledge and collaborate with each others. Moreover as shown in [10], PLM technologies can be used by also enabling the modularized product design for assembly (MDfA), which is found modularity is found useful in collaborative design.

From this point of view an IT infrastructure has to be proposed, enabling project based assignment of different teams within the cluster. This IT environment shall enable first of all the management of the cluster, knowledge and the projects, but it shall also work as a platform for the project teams to operate in as given in fig. 4.

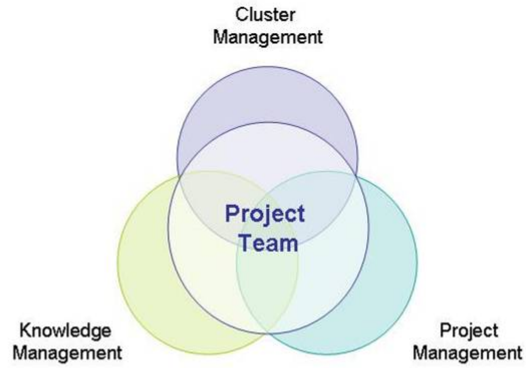


Fig. 4: Positioning of different tasks within the cluster

The cluster itself has a dynamic constitution, which has to be managed by someone. This highlights an important issue: the cluster has to be owned by someone. Ideally a large OEM or a group of OEMs has to create and manage its own cluster. Alternatively an industrial zone can form its own cluster in order to act as a virtual enterprise, wherefore the cluster management team can be appointed annually and the cluster participants shouldn't have a possibility to influence this team directly. This is a business group and they shouldn't be involved in the project management part, which shall be carried out by a project management team.

The project management team is in fact the superior organization to he project teams. The work assignment is carried out by the project management team. Once a requirement arises, the project management team forms the project team from the cluster members, which are using the tools of the cluster during the project. The entire project is carried out than by this constituted project team and the project management team is their customer, functioning as a controller loop. The information arising from the project is captured in the knowledge management center of the cluster.

The knowledge management center of the cluster is both; a team of specialists and a database embedded in the IT framework. Smaller companies mostly have the problem to grow the knowledge by maintaining it. There is a high turnover of associates and the documentation is mostly not in detail. Thus the knowledge management team is an essential part of the whole system. It also makes together with the project management team the technical development plans, by analyzing the capabilities vs. requirements. The customer knowledge management (CKM) given in [16], which is widing the concept of customer relationship management (CRM) can be also implemented into the knowledge management area, underlining the customer focused character of the CCs.

Since the CC shall operate in the real world, which is a highly dynamic environment, changing permanently, the adaptivity and scalability has to be assured. In order to remain adaptive the state definition for advanced control from systems engineering is proposed. Therefore the customer is providing the input and it is also making the consumption by controlling the quality. Therefore the basic system is the Collaborative_Cluster in connection with the customer (see fig. 5).

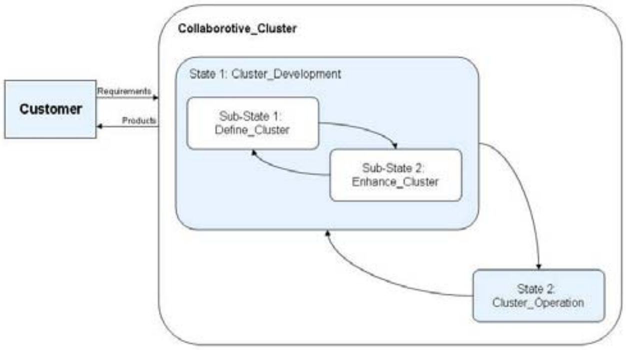


Fig. 5: The State Representation of Collaborative_Cluster

### *B. State Definitions of Collaborative Clusters*

Within Collaborative_Cluster the first state of the clustering is Cluster_Development, including the initial definition of it, which is the first sub-state named as Define_Cluster (see fig. 6). This step is carried out by the Cluster Management Team. The steps to define a cluster from scratch in a specific industry are

1. Define the Areas of Interest (AI) in the chosen industry such as marketing, design engineering, electrical engineering, electronics engineering, production engineering, procurement, integration, finishing, production of sub-assemblies, production of parts etc.
2. Define the desired Level of Expertise (LE) in each AI as measurable metrics
3. Create a list of supplier candidates (SC) and eliminate the ones without quality system, create the reduced list (RL)
4. Determine for each SC in the RL the AI and rate according to the LE
5. Determine for each SC the capacity for all its capabilities
6. Create Company Cards
7. Implement CE basics to the SC
8. Implement IT for cluster management, project management and knowledge management
9. Start Cluster

The second sub-step is Enhance_Cluster for existing clusters, running when there is an idle time localized in the Cluster Management group, which means that the IT infrastructure is also tracking the workload of all teams including project and management teams. Alternatively the external customer complains input also switches the state to the Enhance_Cluster state. This also underlines the customer focused character of the CC. The Cluster_Development state is switched to Cluster_Operation either by Start Cluster command or by external request from the customer, which is also shown in fig. 5.

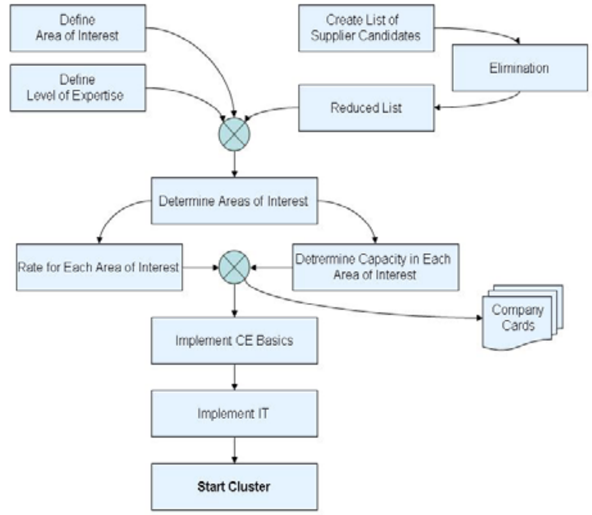


Fig. 6: The Algorithm of Define_Cluster

The state of Cluster_Operation is consisting of the customer, the three management groups shown in fig. 4 and other relevant processes. Being a part of the control mechanism and the initial source and the sink at the end, the customer is the focal point in this state, shown in fig. 7.

There is a 3-level embedded closed loop control systematic. The project management team is the controller in the outer loop using the feedback from the customer and according to this feedback this teams is free to change the constitution of the project team.

The project team formation task is similar to resource allocation and scheduling in general industrial engineering applications and the capacity tracker algorithm is giving the necessary information the project management for the optimum regulation of the project team. This is the inner control loop.

Once the project team formation is completed, the detailed breakdown list of the work packages including the sub-steps is created by the project team and the different items in this list are processed simultaneously. The Schedule Tracker is the middle layer of the global controlling mechanism and it delivers the necessary information to the project management when there are delays in the plan, enabling the reallocation of project teams when needed.

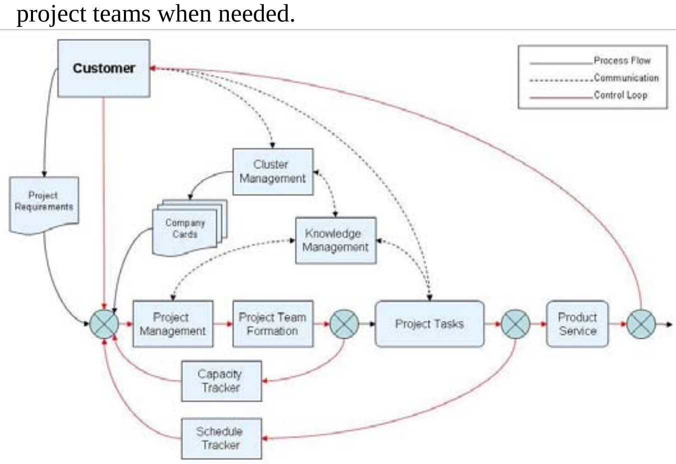


Fig. 7: The State of Cluster_Opearation for IPD

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### C. Important Aspects Regarding IT

The cluster will be hold together by an online IT system, consisting of databases for company information, knowledge and project files by including multi-user graphical interface (GUI), enabling the login of individual members of different levels and groups of the cluster with appropriate access rights to the databases (see fig. 8 and 9).

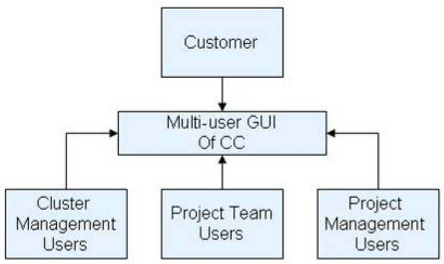


Fig. 8: Multi-user GUI of the CC

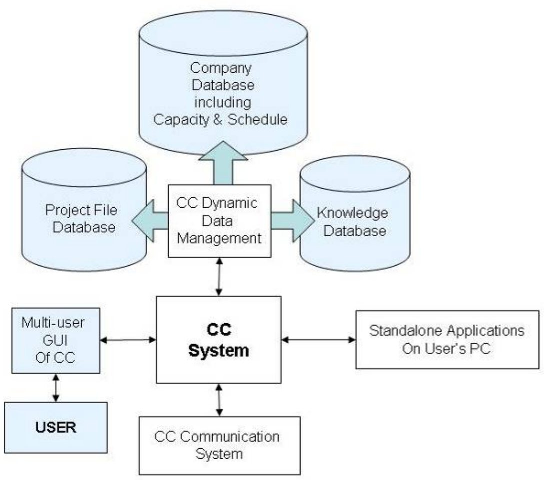


Fig. 9: The workspace of the CC

The traditional communication media cannot provide real-time information exchange and sharing. Therefore, potential problems, such as out-of-date design concept or production plan, may occur due to information inconsistency and communication delays. Moreover functions including part library, collaborative design environment, on-line configuration of modularized parts, on-line negotiation mechanism and enhancing real-time data exchange for the production chain participants have are very critical [10]. Therefore the cluster system has to be able to provide the online collaboration of both: dynamic data management and the formal communication among project members in real-time. There will be also applications running on each cluster user for CAD, CAE, CAM, CIM, ERP or PLM, which also have to be linked or even embedded into the CC System, enabling the user to access these applications directly through the GUI of the CC system, which is therefore spanning the workspace of the CC.

The Internet and remote signaling are a very powerful instrument for continuously monitoring both off-line and system online functions [14], thus the system can make use of the internet protocols, a virtual private network (VPN) system can be adopted to assure security.

## IV. Conclusion

The globalization and the resulting market pressure are forcing companies to realize innovative measures to stay competitive by reducing the costs and development times. Moreover the customer driven product development is another requirement for success. Therefore a customer focused Collaborative Cluster (CC) is proposed here, bringing up companies together, not to compete, but to cooperate with each other.

The approach shown here is not just assembling companies together. It forms a virtual enterprise, capable to merge individual companies together to create an added value from the innovative approach of IPD and CE.

The problems associated with the cooperation and knowledge management issues are overcome therefore by using a software, not only creating and managing the cluster, but also providing a common workspace to bring all cluster participants to the same level, by also integrating the customer into the system.

The necessary algorithms for cluster definition are made and the cluster management system, using the customer as the outer control loop is introduced. State definitions are used to explain the functional constitution of the CC.

As a result, the implementation logic of CCs is successfully developed and summarized, which adoption can improve the existing production oriented clusters, by enabling a synergy in product development. Alternatively it can be used in order to define new clusters of SMEs to act successfully as a big company or bigger companies can lead clusters and integrate the resources of SMEs into their own capabilities.

Nevertheless it must be kept in mind that in order to successfully implement this CC Methodology, there must be one owner of the cluster. It can be a foundation, a big OEM or a group of OEMs, but whoever it is, the owner shouldn't keep knowledge internally, but share it with all participants. Otherwise the cluster can fail. Also all members of the cluster have to be open for the change and they have to adopt the cluster system and use it as the only workspace.

For further research the model based design can be used for the developing and coding of the cluster management system. Since systems engineering principles are used in the conceptual phase of the CC program, the MATLAB & Simulink Environment is planned to be used therefore.

## References

[1] IBM Business Consulting Services, 2007, Aerospace and Defense Transformation, White Paper, available online at: www.ibm.com
[2] Nikolaos Tzokasa, Erik Jan Hultinkb, Susan Hart, Navigating the new product development process, Industrial Marketing Management, Volume 33, Issue 7, October 2004, Pages 619-626, doi:10.1016/j.indmarman.2003.09.004
[3] Isaiah O. Ugboro, Kofi Obeng, 2000, Top Management Leadership, Employee Empowerment, Job Satisfaction in TQM Organizations: an Empirical Study, Journal of Quality Management, 5 (2000), pp 247-272, Pergamon, © Elsevier Science Inc, PII: S1084-8568(01)0023-2

[4] Katja Klingebiel, 2006, A Classification Framework for Automotive Build-to-Order Concepts, ICE 2006

[5] NIS, 1990, Statistics of National Institute of Standards & Technology, Thomas Group Inc., and Institute for Defense Analysis, Business Week, April 30, 1990.

[6] Charles H. FINE, Boaz GOLANY and Hussein NASERALDIN, 2005, Modeling tradeoffs in three-dimensional concurrent engineering: a goal programming approach , Journal of Operations Management 23 (2005) pp389–403, doi:10.1016/j.jom.2004.09.005

[7] TMW, 2007, Model Based Design Seminar Notes , MATLAB & Simulink Presentation.

[8] DIP Project: D12.3 Report on Key Technology Issues in Current EAI, E-Business and Knowledge Management (Enterprise Collaboration with Semantic Web Services).

[9] Roberto Ratti, Sergio Gusmeroli, 2006, An Advanced Collaborative Platform for Professional Virtual Communities, ICE 2006

[10] Amy J.C. Trappey, David W. Hsiao, 2008, Applying collaborative design and modularized assembly for automotive ODM supply chain integration, Computers in Industry 59 (2008) pp 277–287, available online at www.sciencedirect.com, doi:10.1016/j.compind.2007.07.001

[11] Q. Hao, W. Shen, Z. Zhang, S.W. Park, J.K. Lee, Agent-based collaborative product design engineering: an industrial case study, Computers in Industry 57 (1) (2006) 26–38.

[12] EMCC, 2004, The automotive cluster in the West Midlands, UK, Report funded by the European Foundation for the Improvement of Living and Working Conditions, EF/04/93/EN – 2, electronically available on www.eurofound.eu.int , last accessed on Feb. 2008

[13] S. M. SALHIEH, 2001, Collaboration Panning Framework (CPF) to support distributed Product Development, PhD Dissertation, Wayne State University, 2001, UMI: 3037138

[14] Alessandro Persona, Alberto Regattieri, Hoang Pham, Daria Battini, 2007, Remote control and maintenance outsourcing networks and its applications in supply chain management, Journal of Operations Management 25 (2007) 1275–1291, doi:10.1016/j.jom.2007.01.018

[15] Jean-Marc Frayret, 2002, A Conceptual Framework to Operate Collaborative Manufacturing Networks, PhD Dissertation, Universite Laval, National Library of Canada 0-612-72404-2

[16] Chao-Ton SU, Yung-Hsin CHEN, D.Y. SHA, 2006, Linking innovative product development with customer knowledge: a data-mining approach, Technovation 26 (2006), pp 784–795, doi:10.1016/j.technovation.2005.05.005

[17] OECD, 2005, Oslo Manual, Guidelines for Collecting and Interpreting Innovation Data, Third Edition, A joint publication of OECD and Eurostat, ISBN 92-64-01308-3