

ARICON INITIATIVE: BARRIERS IN ADOPTING THE VIRTUAL ENTERPRISE APPROACH IN THE NEW PRODUCT DEVELOPMENT (NPD) CONTEXT

Roxana Belecheanu¹, Kulwant S Pawar¹, Johann c.k.h. Riedel¹, Roberto Santoro², Marco Conte²,

¹*School of Mechanical, Materials, Manufacturing Engineering and Management, University of Nottingham, University Park, Nottingham, NG7 2RD, UK*

²*CE Consulting, Via Terenzio 35, 00193 Roma, ITALY*

This paper provides an overview of the ARICON¹ project and some of its findings to date. ARICON aims to develop a readiness assessment tool and methodology, for evaluating companies' capability to enter and perform in a Virtual Enterprise arrangement. This paper reports on the empirical stage of the project, namely the elicitation of typical problems and barriers for co-operation in a Virtual Enterprise. These problems have been collected through an iterative process, in which questionnaires and interactive workshops and seminars have been used. The participating companies included a large Aerospace & Defence manufacturer, a large automotive manufacturer and 9 SMEs in the aerospace, energy, telecommunications and mechanical sectors.

1. INTRODUCTION

One of the most significant competitive factors for the European industry is the capability of establishing reliable, ICT-based and optimised co-operative networks, especially at peer-to-peer level (Virtual Enterprises), aimed at jointly developing new products by combining complementary skills and expertise.

The emergence of the so-called digital and knowledge economy has had significant impact on the way firms design and develop new products. Nowadays more and more firms are entering into trading alliances with their collaborators during the course of the NPD process so as to enhance their efficiency and competitiveness in rapidly changing and dynamic global environment. Thus the whole domain of New Product Development (NPD) is going through a paradigm shift. Companies' NPD practices are increasingly being digitised – from CAD, 3D models, digital mock-ups, and virtual prototypes through to product data management. Further, many major OEMs and their supply chain trading partners are required to enter into different alliances during the

¹ Standardised Assessment of Readiness and Interoperability for Cooperation in New Product Development in Virtual Organisations

course of the NPD process in order to enhance their efficiency and competitiveness in the global markets. Thus the challenge is to extend the digital NPD to the Virtual Enterprise (VE) context. This implies the ability of extending traditional cooperative schemes (often based on personal relationships and geographical proximity) to new partners having the required technological and manufacturing capabilities, possibly located in different EU countries and characterised by their own business processes and tools, consolidated along years of successful operations. Organisations also have to be lean, agile as well as responsive to the changing needs of their customers. To secure competitive advantage many firms are now forming Virtual Enterprises for design and development of new products.

However, a number of barriers and gaps confront the integration effort and are hampering the wide adoption of the VE paradigm. There is currently no method or tool for assessing an organisation's readiness in a standardised and holistic manner to enter into such an arrangement from the business, organisational, legal, technical, ICT and human points of view. Furthermore, there is an absence of standardised guidelines for engineers and managers on how best to proceed along the VE path.

2. THE ARICON PROJECT

ARICON is an EC funded initiative, aiming to develop a readiness assessment tool and methodology, for evaluating companies' capability to enter and perform in a Virtual Enterprise arrangement. This assessment will be made from a business, organisational, legal, technical, ICT and human point of view. The basis for the assessment is the identification of barriers to Virtual Enterprising in an NPD context, which are structured according to the following areas (Figure 1):

1. Business models and strategies.
2. Organisation and process.
3. Human issues.
4. Innovation and technology.
5. Legal issues.
6. Information and communication technologies.

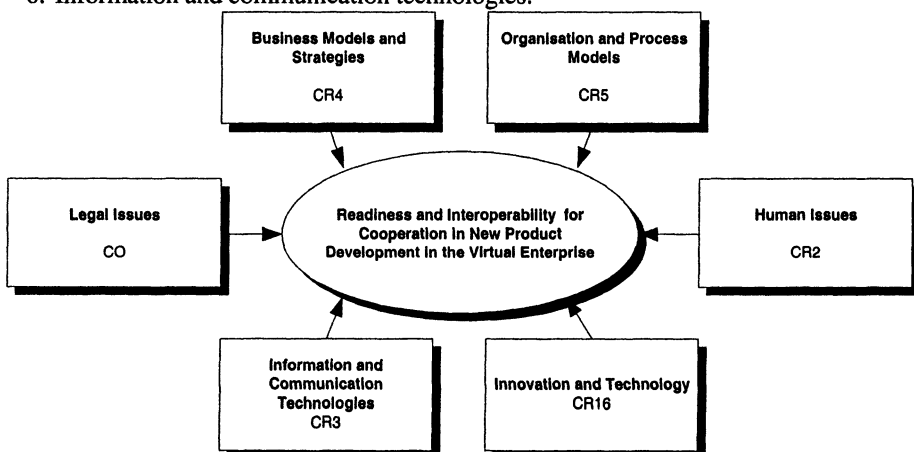


Figure 1: Six-fold assessment of companies' interoperability

Research is carried out on three types of companies: a large Aerospace & Defence (A&D) company, a large automotive manufacturer and 9 SMEs in the aerospace, energy, telecommunications and mechanical sectors. The project will also demonstrate how the assessment tool and methodology can be implemented in companies through pilot projects. An inter-company interoperability evaluation to assess the degree of compatibility between potentially collaborating partners will also be conducted. The developed ARICON methodology and tool will then be proposed for standardisation into guidelines for cooperation and collaboration in the Virtual Enterprise. The production of a European Handbook for Virtual Enterprising will also be initiated, which shall become the key reference.

For reaching these objectives, the sub goals are:

- To develop a framework, methods and tools for assessing a company's internal readiness to enter into a Virtual Enterprise arrangement for the design and development of a new product (software and non-software tools). This will support the interactive assessment by means of questions and ratings. It is also proposed to evaluate the existing capability maturity models, adapt and further develop these for companies contemplating the formation of Virtual Enterprises for the NPD process.
- To develop a framework, methods and corresponding tools (software and non-software tools) for the assessment of inter-company readiness of collaborating partners in the VE. These will identify interoperability gaps for companies.
- To apply the developed tools and methods in pilot projects in small, medium and large organisations at different European sites. The pilots will demonstrate different weaknesses, which will be used to refine the developed tools and methods. It is proposed to measure the performance of the pilots with respect to company internal benchmarks for assessing the benefits of VE. ARICON will also develop corresponding material for awareness raising and training for promoting the development of NPD through VE.
- To propose the developed framework, methods and tools for submission to European standardisation bodies.
- To initiate the production of a European Handbook for Virtual Enterprising.

This paper reports on the empirical stage of ARICON, in which typical problems and barriers in collaboration in VE are identified. Success criteria for co-operation in a VE will also be identified, and based on these, the requirements of the assessment tool will be established. Questionnaires, semi-structured interviews and focused workshops, involving the large Aerospace & Defence (A&D) company, a large automotive manufacturer and 9 SMEs have been undertaken within ARICON for the collection of this set of barriers.

3. EXISTING THEORIES AND WORK

The ARICON project aims to capitalise on the developments of existing theories and approaches. Many examples and studies are available which highlight the benefits of VEs and they advocate its adoption during the course of the NPD process (e.g. Tolle et al., 2000; Mazzeschi, 2001; Santoro and Conte, 2002; Edelman et al., 2003). However, all these examples do not fully address how one should assess an organisation's

readiness in a standardised and holistic manner to enter such an arrangement from the business, organisational, legal, technical, ICT and human points of view. For example, the VIVE – The Virtual Vertical Enterprise initiative (VIVE, 2002) has developed a basic qualification scheme for the Virtual Enterprise business model, while CEPRA (Concurrent Engineering in Practice) has produced an assessment tool for the evaluation of the implementation status of Concurrent Engineering practices in industrial companies. Furthermore, BIDSAVER (Business Integrator Dynamic Support Agents for Virtual Enterprise, (BIDSAVER, 2002)) and GLOBEMEN (Global Engineering and Manufacturing in Enterprise Networks) studied the cooperation from an ICT point of view. The FREE (Fast Reactive Extended Enterprise) project (FREE, 1999) developed a model to improve inter-organisational collaboration, by looking at different areas of collaboration (people, process and resources management).

As a consequence of the work carried out in the above mentioned projects, which have addressed concurrent/virtual enterprise issues according to different, complementary perspectives, the critical areas in cooperation have been structured according to six different categories:

1. **Business models and strategies.** Cooperation must be based on commonly shared business models and strategies, in order to ensure the success of the venture. This may create a number of potential gaps, which may inhibit the set-up of the collaboration. To this end, some companies may, as an example, be willing to keep on operating as a subcontractor and are not prepared to share responsibilities in a peer-to-peer business relationships. Cooperation may also involve the exploitation of markets which may be perceived as risky or to be consolidated. Finally, cooperation may involve a financial exposure which could be outside the reach of the individual partners. The above mentioned issues are just an example of the potential issues belonging to this area.
2. **Organisation and process.** The adoption of common processes and of integrated management organisation implies the need for evaluating the adaptability of internal procedures and organisational structure to the requirements of an extended cooperation. This is needed in order to minimise the number of conflicts between partners during the project development.
3. **Human issues.** Advanced cooperation entails virtual, not physical, co-location. Involved workforce must have additional features (self-motivation, pro-activity, capability of understanding different business cultures) with respect to people used to work in a static, closed environment. Many of the analysed cooperative projects failed to an increased lack of personal trust between partners personnel;
4. **Innovation and technology.** The technological capability is essential when a brand new product is being developed and needs to be assessed with respect to the technological targets of the cooperation;
5. **Legal issues.** Innovative cooperative business schemes need to be supported by “ad hoc” legal framework, which, using existing legal tools, provides cooperation partners with a back-up to the various project transactions (liabilities, IPR management, inter-organisation management and so on). To this end, the ARICON assessment aims to quantify the capability of understanding and adopting new legal policies from a certain industrial partner.

The results of the ALIVE project (Working Group on Advanced Legal Issues in Virtual Enterprise) will also be used, where legal issues arising from the

constitution of the Virtual Enterprise have been identified and analysed (ALIVE, 2002).

6. **Information and communication technologies.** A typical VE problem, as identified by previous VE research (e.g. Wognum and Edward, 1998) is the increase in global project overhead cost due to time spent on design problems and communication disturbances. Each co-operating partner has its own legacy system and design packages. The capability of adhering to a commonly selected platform suitable for that specific cooperation could be a critical success factor in a cooperative framework.

4. RESEARCH METHODOLOGY

In this scenario, the first project period was devoted to the capturing of problems. This has been done according to the following stepwise procedure:

1. Definition of an initial questionnaire, in order to capture an initial barrier set from an interview campaign conducted to ARICON's industrial partners.
2. Consolidation of the list of initial problems.
3. Involvement of a wider industrial group, through industrial association and technology transfer organisation, in order to have a representative sample of European industry concept.
4. Conduction of interactive workshops and seminars to consolidate the final list of problems.

A large Aerospace & Defence (A&D) company, a large automotive manufacturer and 9 SMEs have been the object of study. These companies have been selected due to their need for more efficient cooperation in VE arrangements. For example, the A&D company, in order to maintain its competitiveness, must be able to form new relationships very quickly to deliver to a customer demand. Therefore, the ability to assess the critical relationships between co-operating organisations and the potential impact on the respective businesses is a critical capability for this company. Similarly, the automotive OEM must focus on integrating their suppliers into their internal business processes. This approach, even though is potentially associated to increased quality of collaboration and to minimisation of costs, could be critical if not addressed properly, both at internal and suppliers' level. The project gives the possibility to focus on possible ways to improve this co-operation.

5. FINDINGS

The empirical investigation revealed a number of notable similarities and differences between VE barriers across the companies studied.

5.1 Business related barriers

Table 1 – Business related barriers

	Large A &D company	Large automotive company	SMEs
Common barriers	<ul style="list-style-type: none"> • Choice of partners • Lack of common business objectives; partnerships are all unequal 		
	<ul style="list-style-type: none"> • Conflicts with parent organisations 		
Specific barriers		<ul style="list-style-type: none"> • Utilisation of specific standards and regulation. This may result in limiting the set of potential partners 	<ul style="list-style-type: none"> • Lack of awareness of benefits from the management which may be obtained through the adoption of Virtual Enterprise • Lack of marketing intelligence support when approaching new market due to extended business perspectives arising from co-operation.

- The choice of partners is a common barrier when entering a VE arrangement.
 - Firstly, SMEs tend to avoid advanced co-operations and use mainly customer-supplier relationships (or, in some cases, temporary consortia) in order to limit their own responsibilities and liabilities.
 - Secondly, the large companies in the defence sector experience constraints in the choice of partners, but for a different reason: in this sector partnerships are often dictated by political reasons, since the government is the main customer of the end product.
 - Thirdly, the automotive company finds that the utilisation of specific standards and regulations limits the choice of potential partners.
- The lack of common objectives is a typical problem in Virtual Enterprises:
 - The large companies experience that, in a partnership, the partner with a small share of business treats that project with low priority among all the projects he is involved in, while the partner with a large share gives the project high priority. This is why partnerships are completely unequal. Therefore, there is a need for a profit sharing based partnership, with an attitude towards maximising the overall profit rather the own share of profit.

5.2 Organisation and processes related barriers

Table 2 – Organisation and processes related barriers

	Large A&D company	Large automotive company	SMEs
Common barriers	<ul style="list-style-type: none"> • Lack of integrated Project Management tools and of formalised processes procedures, across the company. • Formalisation and management of inter-organisational processes 		
Specific barriers		<ul style="list-style-type: none"> • Organisation characterised by a hierarchical structure, with insufficient delegation at project level. This is expected to create strong inertia during the co-operation activities 	<ul style="list-style-type: none"> • Lack of cost control procedures. Costs are in general controlled by monitoring the most important and costly items. Process modelling and formalisation for co-operation, including change management, are not practised and co-operation is managed on a case by case basis.

All companies experience a product oriented mentality, and insufficient effort is geared towards project and process aspects. With this respect, there is a need for better awareness and effort towards designing the processes as good as the products are designed:

1. Firstly, an inadequate formalisation of the internal processes is experienced by SMEs. In contrast, in the large companies, although processes are in place and codified, they are either not unified across the company or not followed by the project teams. Thus, processes tend to be written by the people who run them, not by those who must follow them, and therefore each project team tends to ignore them and follow independent procedures (“... *there are 2000 projects, like 2000 sovereign states... everyone is doing things in their own way*”). This results in Project Management problems and in a misunderstanding of cost and time pressure. A mechanism to improve the process formalisation is thus needed.
2. Secondly, the situation is complicated even more as result of the VE arrangement. This results in difficulties in tracking inter-organisational process steps and in conflicts between the built-in processes of the partner companies. Therefore, collaboration is often perceived only as a matter of solving such conflicts.
 - For example, in the automotive company there is no dedicated system for keeping track of the inter-organisational process, and the only means for achieving this is by tracking the history of the exchanged files, mainly CAD files.

5.3 Innovation and technology related barriers

Table 3 – Innovation and technology related barriers

	Large A &D company	Large automotive company	SMEs
Common barriers	<ul style="list-style-type: none"> • The biggest technical difficulties occur due to discovering problems so late in the design, that solving them affects a lot of the interfaces between product parts • Adversarial attitude of partners, lack of co-operation in innovation • Difficulty in integrating between areas of different competencies and of using to full extent partners' specialised skills, due to a lack of consolidated models according to which work can be distributed among partners • Incompatibility of software systems used 		
Specific barriers	<ul style="list-style-type: none"> • Speed of evolution of technology in the field • Complexity of the product (no two products are the same) 		<ul style="list-style-type: none"> • Lack of catalysts/integrators, needed for the success of the innovation process. Technology scouting, identification of available and emerging technology from the competency centres or professional association are the base activities for this kind of services

All companies experience a lack of co-operation in the innovation process, due to the fear of loss of knowledge. For example, the automotive company identified that collaboration in the technology innovation field is usually made in the pre-competitive phase (through public funded projects), but as soon as the outcomes start to show possible industrial applications, collaboration usually is not maintained. In general, a lack of catalysts/integrators for the success of the innovation process was seen. Similarly, the A&D company identifies a higher frequency of collaboration and interaction among partners in design only at micro level, but not at integration level.

Furthermore, the A&D company is usually confronted with problems arising from the complexity of the product and due to the nature of the military sector, like the fact that technology changes too fast from one product to another, almost 1-2 generation leaps between two subsequent products (especially in the case of digital technology). Also, the incompatibility of partner's programmes and legacy systems is often solved by the prime contractor imposing the use of a certain design tool (e.g. CAD, PDM) to its suppliers/partners. The suppliers must also perform the necessary training.

5.4 Human barriers

Table 4 – Human barriers

	Large A &D company	Large automotive company	SMEs
Common barriers	<ul style="list-style-type: none"> • Lack of rewarding mechanisms linked to co-operation. People prefer to remain close to their hierarchic boss who is seen as the main promoter of career advancement 		
Specific barriers	<ul style="list-style-type: none"> • Transfer of knowledge between projects and learning from past experience • Adversarial attitude due to the negative experiences in past projects 	<ul style="list-style-type: none"> • Lack of rewarding mechanism for knowledge sharing and for motivating people to use new ICT tools. The tools and infrastructure are available but there is no commitment for cultural issues. • Human Resource management problems caused by the re-insertion of personnel used to operate in a VE context in day by day operation. 	<ul style="list-style-type: none"> • Difficulties in interpersonal communication skills. • Lack of specific training for people assigned to work in VE projects. The inter-organisation workforce must cultivate and develop self motivation, pro-activity and capability of understanding different business cultures.

The A&D company experienced specific problems to collaboration: there is a lack of learning from past experiences across the company. Lessons are learned at individual level, but not at company level. Nevertheless, even when people have experience with working on VE projects, it does not always mean that making old mistakes is avoided. However, it was found that negative experiences from past projects influence collaboration in future projects.

5.5 Information and Communication Technologies (ICT) barriers

Table 5 – Information and Communication Technologies barriers

	Large A &D company	Large automotive company	SMEs
Common barriers		<ul style="list-style-type: none"> • Lack of information about the benefit (usually not immediate) coming from its use (resulting in that the personal feeling that there is only additional work to do in learning and utilising the new tool) 	
Specific barriers	<ul style="list-style-type: none"> • Problems in collaboration are also caused by immature technology. 	<ul style="list-style-type: none"> • Insufficient motivation for the use of an ICT tool. 	<ul style="list-style-type: none"> • Electronic communication is not recognised as a valid transaction medium at

	<ul style="list-style-type: none"> • There is a need for consistent semantics (terminology) across the organisation (inc. documents, SW, etc.) • There is no investment in IT to support the maintenance activity. • Each partner is advised by its own IT experts. • Technology is not used effectively. 		<p>high level due to the lack of a proper normative settlement.</p> <ul style="list-style-type: none"> • Lack of a direct Internet connection and the access to Internet is achieved through a dial up mode or is filtered through the server of the mother company. • Lack of individual e-mail system and, in general, of advanced connectivity.
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5.6 Legal issues

Table 6 – Legal issues

	Large A&D company	Large automotive company	SMEs
Common barriers	<ul style="list-style-type: none"> • Availability of existing legal policies and regulations. When a company is a subsidiary of a big group, it could be subjected to the group's policies and to the higher level approval on the most important decisions. 		
Specific barriers	<ul style="list-style-type: none"> • IPR issues: when 3 main suppliers are competitors, they all need to make sure that there is no loss of IPR 	<ul style="list-style-type: none"> • The lack in delegation empowerment at decisional level can cause delays not acceptable in a VE environment. The project responsible in most cases and the "Managing Director" for the formal signature are empowered to take decisions which would imply legal consequence. This could slow down cooperation 	<ul style="list-style-type: none"> • Preference to existing personal relationships for finalising business and consequent insufficient attitude to exploit partnerships entailing formal agreement with new partners. • Lack of model contracts, suitable for supporting the quick establishment of a cooperation. In most cases, SMEs do not have available their own legal staff and this may introduce a barrier in case a predefined approach does not exist. • Unawareness of the legal implications of information exchanged through the Internet. Current way of working often implies that engineering information (e.g. drawings) is transferred to both the customer and the partners by using conventional means: these include fax, courier and e-mail

		timeliness and capability to react to external event.	attachment. Electronic documentation is accepted as an advanced release of relevant paper data packages.
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6. DISCUSSION

It was shown in this paper that the companies interviewed experience a series of problems which are, in majority, typical to a Virtual Enterprise and due to the decentralised and heterogeneous nature of the Virtual Enterprise business. The central problem is a lack of commonality of various aspects of the business (e.g. business objectives, processes and working practices, semantics of product data, design technology, ICT platforms, engineering standards, and not the least culture).

These problems are manifested in different forms and have different consequences at each of the companies studied, depending on the nature of that industry and of that partnership. For example, in the A&D company, these problems are amplified and combined with a high complexity of the product and process, adversarial attitude of the partners (for political reasons) and the lack of ownership and leadership typical to a peer-to-peer partnership. In the case of the SMEs, these problems are amplified by a lack of awareness, within the management, of the VE difficulties, a lack of training and/or past VE experiences and a lack of proper ICT and legal infrastructures.

A common solution to all these problems is evident. From the partnership point of view (viewed as one organisation) there is a need for a more careful preparation of the VE, with a strong common business model. Thus during the VE setting phase (i.e. before the product design and development start), there is a window of opportunity to establish, through a legal contract, all the liabilities, IPR issues and profit sharing rules. From the partners' perspective, more commitment towards the VE business and better prioritisation of the VE with respect to other internal projects are required.

However, the implementation of any solution towards common approaches must be carefully thought. Thus, while it is complex and time consuming to set up a minimum common project policy level between partners for very large projects (like in the A&D industry) and while it is more practical manageable to do that for small projects (e.g. SMEs), in the latter case the duration of the project (sometimes as small as a few hours) might not justify that. Instead, one of single most important management solution that all VEs agree on is the establishment and nurturing of mutual trust.

The paper thus shows that a well designed assessment methodology of collaboration in different VEs must take into account in detail the specificity of the VE arrangement and of the companies involved in it, the idiosyncrasies of those industries and must acknowledge the some of these situations are problematic in their nature and are not practically solvable. Therefore the ARICON assessment methodology will be based on reference models of the VE typologies identified from the project partners and will take the form of a guided selection of assessment scenarios.

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