Towards a Typology for Business Solutions in Complex Engineering Service Systems

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Abstract
The process of servitization for manufacturing firms (Salonen, 2011; Oliva and Kallenberg, 2003; Teboul, 2006) has been studied so as to consider how manufacturing firms can combine products and services in order to provide business solutions for their customers (Spring and Araujo, 2013; Cantù et al, 2012). Considering the complexity of relationships between firms engaged in the provision of solution, authors as Tuli *et al.*(2007) and Sawhney (2006) describe solution transactions as a relational process, identifying the temporally linked sequence of activities in which customers engage to solve a problem. More recently, studies have been developed to the understanding about how firms provide business solutions not only as a relational, but also a network-focused process. However, there is still a gap in literature for a classification of business solutions in this new approach. The aim of this paper is to purpose a typology for business solutions as a market shaping process, taking complex engineering service systems as the context of analysis. A qualitative and exploratory research

is adopted, using a case study approach in the aerospace industry. In order to capture the essence of the network, a triadic method is applied in the selection of cases (Choi and Wu, 2009a,b). The data reveals four different categories of business solutions provided in complex engineering service systems:1) solutions before manufacturing; 2) solutions related to manufacturing; 3) solutions for product performance and 4) solutions for innovation. This paper has theoretical and managerial contributions by presenting a typology for business solutions as a dynamic and variable combination of products and services over time. It also contributes to the understanding of servitization as a market-shaping process.

Keywords: Complex Engineering Service System, Servitization; Solution; Aerospace industry

INTRODUCTION

Have you ever done a jigsaw puzzle? A solution business model can be compared to "an immense multi-dimensional jigsaw puzzle in which both the shapes of the pieces shift over time, as do the interconnections between them, with consequences for the overall picture of the market itself" (Ferreira et al , 2013, p.1100). This means that market shaping processes in the case of solutions are reciprocal: the solution processes influence the shape of the market, whilst at the same time being influenced by forces at play in the market. As argued by Cantù et al. (2012, p. 139), "each actor takes part in resources combination both as provider and user of resources…[and] shapes the development of business relationships". Considering the provision of solutions, Spencer and Cova (2012) claim that it is necessary to go beyond the dyads/focal networks perspective to incorporate a market-based approach to marketing solutions.

The discussion about solutions from a network-focused perspective is particularly relevant in processes of servitization in complex engineering service systems. Authors such as Salonen, (2011); Teboul (2006), Oliva and Kallenberg (2003) claimed that the market's complexity is forcing traditional product-manufacturing companies to change their position in the goods-services continuum by continuously extending the service business to their offers. For authors such as Spring and Araújo (2009) and Ford et al (2003), manufacturing firms need to provide a combination of products and services as mixed offerings (Fort et al, 2003) that can be called up as solutions (Kapletia e Probert, 2010). Nevertheless, according to Storbacka and Nenonen (2011), a solution, in itself, can be understood as a discourse on the market and its evolution, or as a market scripting.

In complex engineering service systems, such as the aerospace industry, companies usually integrate solutions by offering to design and combine components into a system and provide services to operate and maintain the system over its life cycle (Helander and Möller, 2007). According to Ng et al (2011), increased pressure on budgets means that customers are increasingly seeking greater value for money, and long-term service contracts to support complex engineering products are becoming the norm. Customers recognize the need for close integration of service systems with their own business systems and are taking an active role in working with their suppliers to ensure those services deliver the outputs they need in an affordable way. Inspite the fact that some studies have been developed to the understanding about the process of business solutions by a network-focused process (Cova, authors as Briscoe et al (2012) and Ng et al (2011) affirms that much emphasis is placed on the static nouns of a system, rather than the dynamic verbs which are more significant in facilitating the understanding of complex outcomes**.**

In order to investigate this phenomenon, the aim of this paper is to purpose a typology for business solutions as a market shaping process, taking complex engineering service systems as the context of analysis. We develop the analysis in the case of the aerospace

industry, applying a triadic method in the selection of cases in order to capture the essence of the network (Choi and Wu, 2009a,b). A qualitative and exploratory research process of a case study is adopted, that can be seen as single case and a multiple case study, as the single case of the integrator serves as umbrella for the cases of triads (Yin, 2003). The dynamics at play are not those of a triad taken individually, but rather those between triads, taken from the perspective of a solution business integrated approach. The results of the case studies are then presented and discussed collectively.

The paper first discusses the process of servitization of manufacturing firms as a market-shaping process, presenting the claim for an expanded typology of business solutions. Thus, the concept of complex engineering service systems is presented, describing the role of manufacturing firma as a system integrator for the provision of solutions, by mobilizing and servicing actors far beyond its boundaries. The results of the case studies are presented and discussed in relation to the preliminary findings. The paper brings theoretical contributions regarding servitization of manufacturing firms and the combination of products and services as business solutions over time. The typology presented has also managerial contributions, providing guidelines for managers that handle with the provision of business solutions in complex engineering service systems.

SERVITIZATION AS A MARKET-SHAPING PROCESS: EXPANDING THE TYPOLOGY FOR BUSINESS SOLUTIONS

Ever since the mid-1990s, in all sorts of industries, companies such as aircraft manufacturers that have traditionally made and sold standalone products have been changing their strategies (Nordin & Kowalkowski, 2010). Indeed, manufacturing companies are developing the capabilities and organizational structures required to combine physical components and services provided by a variety of internal and external suppliers (Wise & Baumgartner, 1999; Davies et al, 2006). Regarding the process of servitization (Spring and Araujo, 2013; Cantù et al, 2012; Salonen, 2011; Oliva and Kallenberg, 2003; Teboul ,2006), significant applied service research has been undertaken in manufacturing companies as a result of their move towards both a service-oriented approach and an offer of comprehensive customer solutions. Traditionally, authors describe a solution and its value as an integrated product/service combination with improved final outcomes for the customer (Kapletia and Probert, 2010; Sawhney, 2006). Customers expect a solution to include processes directed at understanding their requirements, customizing and integrating products, deploying them, and supporting them on an ongoing basis (Oliva and Kallenberg, 2003; Tuli et al, 2007). As the process of servitization of manufacturing firms is related to the combination of products and services as solutions, the understanding of the development of this concept in the business-to-business marketing field brings contributions to this process.

For Spencer and Cova (2012), an evolution for the concept of solution can be identified in the extant literature. The combination of products and services as integrated offerings can be described in a variety of concepts and terms, such as Bundling (Guiltinan, 1987), System Selling (Mattson, 1973), Full Service (Stremersch et al., 2001), Service Package (Fitzsimmons and Fitzsimmons, 1994), Product Service (Frambach et al.,1997), Installed Base Service (Oliva and Kallenberg, 2003), Solution (Miller et al., 2002) and Integrated Solution (Davies, 2001). For Park et al (2012), not all of these concepts are particularly different; some embrace the same concept under different terminology, while some are only variants of other concepts. For Spencer and Cova (2012), the concept moved from a firm-centric logic to dyad-centric logic to market-centric logic.

By a firm-centric logic, solutions can be understood as a customized and integrated combination of goods and services for meeting a customer's business needs (Galbraith, 2002;

Davies et al, 2006; Sawhney 2006). In this first phase, the focus was on issues related to the combination of products and services as the content of offerings, and more particularly, the service dimension of offerings (Ceresale & Stone, 2004; Oliva & Kallenberg, 2003; Galbraith, 2002). This was a firm-centric logic considering solutions as related to the development of value propositions, these often being considered as 'integrated' or 'total' solutions. (Davies et al, 2006; Stremersch and Tellis, 2002).

However, authors such as Kapletia and Probert (2010), Tuli et al (2007) and Sawhney (2006) suggest that the effectiveness of a solution or a "solutioning system" depends not only on supplier variables but also on several customer variables, from the perspective of a dyad-centric approach. For Tuli et al (2012), customers view a solution as a set of four customer–supplier relational processes, characterized by "a set of four relational processes" that are: "1) Requirement definition: customers are not fully cognizant of their business needs and should have discussions with the supplier to elaborate them; 2) Customization and integration: customization involves designing, modifying, or selecting products and services to fit a customer's environment and integrating them into a coherent whole; 3) Deployment: deployment refers to the delivery of the integrated solution and its installation within a customer's environment; 4) Post-deployment support: post-deployment support is more than providing spare parts, operating information, and routine maintenance; post-deployment support also includes deploying new solutions in response to customers' evolving requirements (Tuli *et al.*, 2007, p. 5)". Sawhney (2006) also identifies the customer activity cycle as the temporally linked sequence of activities in which customers engage to solve a complex problem. This cycle consists of three phases (Sawhney, 2006, p. 372): 1) Pre or before: when customers are deciding what to do to get the desired result – searching, deciding, acquiring; 2) During: when customers are doing what they decided on – installing, using, operating; 3)Post or after: when customers are keeping things going – reviewing, renewing, extending, upgrading' and updating. The concept of solution is not seen as an integrated solution provided by the supplier, but is reconceptualised into the term "customer solutions" (Spencer and Cova, 2012).

However, drawing on the market-shaping theory (Kjellberg and Helgesson, 2006 and 2007), Spencer and Cova (2012) argue that solution is not a dyadic issue; it emerges from the notion of a value creation network. For Spencer and Cova (2012), value is co-created between supplier and customer (and their related network actors), plus other market actors, and solutions can be seen as a 'market solution', not just as a 'customer solution'. Solutions can be described according to a market-centric logic, being co-created by different actors who really do veritably shape the markets – and the networks – that they engage in. From this perspective, "a solution is in itself a discourse on the market and its evolution" (Spencer and Cova, 2012, p. 1584). Market actors shape the exchange taking place, as well as outcomes or expectations as regards value.

Despite the fact that actors as Park et al (2012) present a taxonomy to clarify the commonalities and differences among all relevant concepts, all these studies have given contributions by considering solutions as a dyadic and linear combination of products and services over time (Spencer and Cova, 2012). But, as a relational and market-shaped process, the provision of solution requires all actors to continually and mutually reconfigure their activities (Ferreira, et al, 2013). As the process of servitization of manufacturing firms is related to the combination of products and services beyond the boundaries of the dyadic-focus (buyer-costumer), "the integration of products and services as business solutions is still in its infancy to be further advanced (…) and a classification scheme of the integration of products and services is required to yield practical implications for designing and developing integrated offerings." (Park et al, 2012, p. 529). Taking this into account, the next section describes a

literature review related to complex engineering service systems, for which the discussion about solutions as a market-shaping process is particularly relevant.

THE PROVISION OF BUSINESS SOLUTIONS IN COMPLEX ENGINEERING SERVICE SYSTEMS

Complex systems are systems with interdependent parts. Interdependence means that we cannot identify the system behaviour by just considering each of the parts and combining them. Instead we must consider how the relationships between the parts affect the behaviour of the whole. Complexity within engineering service systems generally arises from their increasing scale and/or number of components (Ng et al, 2011). Complex systems are constantly adapting and their interactions can have emergent effects upon outcomes, which are sometimes unpredictable.

For Normann (2001), every service system is both a provider and a client of a service that is connected by value propositions in value chains, value networks, or value-creating systems. Davies et al (2007) show that firms are adopting a variety of hybrid organizational structures that lie between the two ideal types of systems selling and systems integration. In a complex engineering service system, the provision of integrated solutions is performed by the manufacturing company, which plays the role of solution integrator (Davies et al, 2007, p. 185): 'a prime contractor organization responsible for the overall system design and integrating product and service components supplied by a variety of external suppliers into a functioning system'. Cova and Salle (2008a, 2008b) contend that creating superior value for customers means mobilizing and servicing actors far beyond the boundaries of the buying center, supply chain, and customer solution net. Rather than passing through the consecutive relationships in a service supply chain, subsystem service suppliers participate directly in the value co-creation process with the system supplier and the customer.

Cousins and Spekman (2003) argues that, when managing supply, it is not enough to observe if the functions that arise from the specialization of activities and resources are complementary or not. Buying companies must try to identify suppliers that, due to their characteristics and capabilities, may leverage their own resources and activities and foster their ability to deliver superior value to customers. The evaluation of the supplier's potential should include the analysis of its relationships within other supply chains and the value that these connections may bring to the buying company. Alongside the effects of their dyadic relationships, firms also endure the direct and indirect effects of their counterparts' own relationships that flow across the network through interconnected relationships. As discussed by Hertz (1992), since each relationship may affect other relationships positively or negatively, the degree of interdependence in a network varies with the content, intensity and symmetry of the relationships.

Spring and Araújo (2013) and Araujo et al (1999) point out the need to clarify the nature and benefits that supply relationships can bring to customers. Suppliers differ widely in their capabilities and in what benefits they can offer. Some suppliers may provide benefits in terms of cost rationalization whilst others can act as sources of new ideas and practices. The contributions from suppliers will depend on how "close" the relations are, for example, in terms of the degree of involvement (Gadde and Snehota, 1998). On the other hand, the higher the involvement between the parties in terms of coordination of activities and interaction among people, the more demand for resources there will be on the relationship. Thus, the benefits of closer involvement with suppliers must offset the investments needed to set up and maintain the relationship (Araujo et al, 1999). For Spring and Araújo (2013), in this sense, a network is seen as an inert-connected set of productive opportunities and it is important for

the understanding of both institutional and ontological connections between service offerings and the products, factories, firms and network with which they are associated.

Considering the supply chain for complex engineering systems, work by Helander and Möller (2007) and Cova and Salle (2008a, 2008b) place emphasis on the fact that value co-creation can only be understood via consideration of network mobilization. Helander and Möller (2007) affirm that a system supplier's customer strategy is closely related to its roles for the customer. The key activities are described as links between supplier and customer, and the coordination mechanisms are presented as a horizontal continuum across activity links. Moreover, both suppliers and customers may actively use the resources and capabilities of third parties, called "network". Indeed, the solution provider often needs partners for creating and maintaining the system. The partner network can be seen to enable the supplier to focus on activities which are difficult to standardize and require highly specialized expertise, for instance, application and business consulting. "The consistent performance for the customer seems to require from the supplier excellent network management capabilities, both at corporate and account team level (Helander and Möller, 2007, p. 725).

Providing any complex business-to-business solution involves an interdisciplinary effort—incorporating people, technology, value propositions, and shared information –which is matched to each opportunity (Maglio and Spohrer, 2008). In this context, Ng et al (2011) affirm that the service encounter embodies value-in-use, value which is jointly co-created between the customer and the firm for mutual benefits (Ng et al, 2011; Payne et al, 2008; Prahalad & Ramaswamy, 2003). Ng et al (2011) also affirm that to meet the full value in use of the firm's offering, three integrated simultaneous transformations are required; people, material/equipment and information. Mastery of these three simultaneous transformations within a multi-organisational context and the interactions between them will provide a firm with sustainable returns and a competitive advantage. However, Ng et al (2011) affirm that much of the literature has taken the dyadic firm/customer relationship as a unit of analysis and has not articulated the broader business nature of complex engineering service delivery. Considering this, the next section presents the methods applied to reach the aim of this investigation.

METHODOLOGY

This study aims to purpose a typology for business solutions as a market shaping process, taking complex engineering service systems as the context of analysis. Whilst partially framed by solution business theory, the research is exploratory, and hence calls for case research for theory-building purposes. Case study research is a method extensively used in management to investigate the decisions and behavior of groups and individuals within organizations and in inter-company relations (Barratt et al, 2011; Dubois & Gadde, 2002; Easton, 2003). This methodology is developed to examine complex problems with a view to identifying theoretical implications from a theory-building perspective. In particular, the method draws on the study of one or more cases of a given phenomenon in order to acquire an improved understanding of, or form a general conclusion about, the topic under study.

Some authors have argued that a single case study is justified or even preferable under certain conditions (Easton, 2003; Siggelkow, 2007): a single case study can show the impact of a large number of powerful and active contingent relations and the way they operate. Other authors (Eisenhardt, 1989; Eisenhardt & Graebner, 2007) argue that for theory building purposes the use of multiple cases is likely to create more robust theory than single case research. Multiple cases can augment external validity and help guard against observer bias (Eisenhardt & Graebner, 2007; Yin, 2003). A range of between four and ten cases is usually considered appropriate (Barratt et al, 2011; Eisenhardt, 1989). With fewer than four it may be

difficult to capture the complexity of the real world and more than ten cases poses problems for the researcher in cognitively processing the data. Weighing up the pros and cons of single versus multiple case approaches, we considered that the optimum way to investigate this theme in the aerospace context would be to combine the two approaches, as the single case of the integrator serves as umbrella for the cases of triads (Yin, 2003). This choice has a direct impact in terms of sampling process and case selection, as detailed in the next section.

Case Study

In a similar vein to recent research into complex engineering service systems (Ng et al., 2012), here we choose to investigate the aerospace industry, considering triads of actors as the unit of analysis (Vedel et al., 2012; Van der Valk and Van Iwaarden, 2011; Peng et al., 2010; Choi and Wu, 2009a, b). Typically, a triad of actors is involved in any outsourcing situation: the buyer, the supplier and the buyer's customer. In manufacturing, the buyer acts as a bridge between its supplier and its customer and maintains this bridge position before, during and after the outsourcing (Choi and Wu, 2009a,b). In each triad, we focused on the relationship between one major aircraft manufacturing company in the world and its counterparts, as customers and service providers. The aircraft manufacturing company was considered the common hub for all triads, providing the focus, facilitating comparison and identifying its business network relationships for the provision of solutions.We considered a Service Provider as the third party (not a supplier of manufactured goods), to afford a clear illustration of service provision in business networks.

Relationships involving six firms in a solution system were analysed: one major manufacturing firm (as the common focal point of each triad), four service providers (two maintenance and repair service firms, one aftermarket services firm and one onboard entertainment services firm) and one customer firm. For a case study approach, the six firms were analysed from different perspectives: 1) the nine preliminary dyads constituted between them, 2) the four separated business triads developed for the provision of services, and 3) the inter-triads relationships related to the provision of solutions over time. Figure 1 below illustrates the relationships analysed:

Figure 1 – Dyadic and triadic relations developed by six firms as part of the EBR solution system

In the analysis of data, we first study the case of the specific aircraft manufacturer, EBR, and its integrated solution approach. The aim is to further the analysis of this actor's perspective as regards the development of the relations in which it is involved in the provision of solutions. This choice offers the advantage of providing an overview for the focal firm whilst at the same time supporting development of managerial implications. The second level of focus concerns the case of the dyad comprising the aircraft manufacturer EBR and the airline NATAIR, with emphasis on the contract between them for the supply of a batch of E-jet aircraft in commercial aviation. The aim here is to better understand the role of this relationship with the customer in the extant development of associated relationships in the provision of solutions.

The third level of focus includes all triads developed between EBR and NATAIR with each one of the four service providers identified. The triads, all related to the EBR solution approach, lead us to the understanding of how relationships are developed over time between the firms and how these relations establish the engagement of manufactures, customers and suppliers as actors in the provision of solutions. Then, at a fourth level, we investigate EBR's

overall approach relating to the inter-triads involving EBR, NATAIR and all service providers. This approach allows us to find evidences in order to understand how the provision of solutions is developed as a relational and networked process. Although taxonomies are frequently derived from cluster analyses or other multivariate statistical techniques, they can also be obtained through direct observation (Wheelwright and Hayes, 1985).

Data collection

Data were collected from local visits and interviews with managers. In each triad, at least one manager was interviewed (including within the aircraft manufacturing firm), to identify 'informed' managers who possessed most knowledge about the relationships established in each triad. Face-to-face interviews were conducted in major cases, involving a total of 28 hours' interviewing. Table 1 below shows the firms investigated and how the data were collected via interviews in each firm. The respondents' identities are also presented.For reasons of confidentiality, the names of the companies and respondents have been disguised:

Table 1 - Firms investigated and characteristic of interviews

For improved reliability, following the data compilation process, the histories of the triads were presented to the interviewees for validation. Archival sources (e.g. documents and historical records) were used to contextualize the interviews. Three interview scripts were also prepared: one for interviews with the aircraft manufacturer, one for the service providers and one adapted to customer interviews. Initially, the triads were identified through interviews with managers in the manufacturing firm. Drawing on this identification, managers of service providers and customers were contacted and visits were organized. All scripts contained questions about the development of each dyad (Manufacturer-Customer; Manufacturer - Service Provider and Service Provider-Customer) and the triad (Manufacturer-Service Provider-Customer).

This being exploratory research, the scripts contained open-ended questions, covering various themes: What products / services are exchanged as solutions between the parties? How can the history of relations between companies be described? How are contracts established between the companies? How are interactions and business processes between companies developed for the provision of solutions? What is the importance of each party in the provision of solutions? What are the main sources of conflict between companies? Views regarding relations were collected from all parties; i.e. Manufacturer, Service Provider and customer managers expressed their views on the relationship of each dyad and triad.

Data analysis

The data collected through in-depth interviews were systematically transcribed and subjected to content analysis (Krippendorff, 2004). At the analytical stage, units used for content analysis purposes were sentences, paragraphs and phrases.Open coding was conducted by noting comments in each interview. Codification and interpretation processes were undertaken using software for analysis of qualitative methods, the QSR NVIVO 10 for windows. Data analysis is within-case and cross-case oriented. The findings are presented in such a way as to form a chain of evidence (Barratt et al, 2011).

RESULTS

The narratives of the development of the relationships involving EBR, NATAIR and the four service providers are summarized below. These have deliberately been curtailed as each case includes a considerable amount of data.

EBR, the Aerospace production context and the solution approach

EBR is one of the world's main aircraft manufacturers. With a global customer base and important internationally renowned partners, it offers Commercial, Executive and Defense aircraft. Aircraft manufacturing involves high technology, high complexity and the development of a global business network capable of providing support for the operating of the product over time. The aircraft is a long-lasting product and requires constant maintenance and updates by the manufacturer. This means the establishment of a long-term relationship between Manufacturer and Customer, with constant interactions.

According to the interviewees, EBR produces aircraft while at the same time offering packaged services specific to the requirement of each segment which go beyond the usual aircraft-related services: '*We offer a product that is a solution*' (manager EBR 03). All in all, integrated solutions appear to be a win-win approach: '*The development of partnerships is essential to give the necessary support to our customers around the world. It is through these partnerships that we get the best cost-benefit ratio, both for us and for our customers'* (manager EBR 03).

In terms of solution based strategies, EBR increasingly offers integrated solutions going downstream with a high degree of integration of the offering within the customer's value chain, including aftermarket services. Consequently, EBR develops a portfolio of service providers from a network of potential partnerships, by mobilizing the appropriate service business units to offer services over an aircraft's life cycle: '*For better management, the strategy is to dispose a portfolio of partnerships allowing service provision around the world'* (manager EBR 01). EBR has both established its own service units (the EBR Service Centre), and has also set up a number of strategic partnerships to ensure the highest service standards for the EBR fleet worldwide.

The main dyad "Manufacturing firm –Customer": the EBR-NATAIR case

NATAIR is a commercial airline that commenced business in 2008. The airline's business model focuses on stimulating traffic and boosting the national economy through a formula combining low prices and high quality services. In 2009, it purchased a set of E-Jets direct from EBR. According to NATAIR managers, the EBR solution approach is what led to this choice: '*EBR sells a package. We bought the aircraft along with a range of services* (NATAIR 02). Even in the early stages of the relationship between EBR and NATAIR in 2008, the service dimension was at the heart of the contract and certain service providers were asked to participate in the discussions, such as the engine maintenance and repair service providers AFTERPARTS and MOTORSERV: *'We can't have our aircraft laid up. Once an aircraft is in the hangar, we are losing money. We need to keep our aircraft both in the air, and safe to fly'* (NATAIR 03). NATAIR chose to build its fleet around EBR for the most part due to '*its business to business networks for the provision of services related to maintenance and repair. If this network had not existed, we probably would have selected another manufacturer*' (NATAIR 04).

Relationships developed between EBR and NATAIR can be better understood by consideration of the different phases structuring a multipartite partnership of this kind. We identified four phases: a pre-contract phase (Model Choice and Commitment) and three subsequent post-contract phases (Joint Definition; Manufacturing; Delivery/Operation). According to Interviewees NATAIR 01 and NATAIR 02, both the aircraftas well as the supplier's overall abilityto provideservicesthroughout thelife cycleof the system being offered are analyzed. The structure of the system supplier's supplier portfolio is a critical issue, fromthe early stage of the relationship to the Delivery/Operation phase, as can be observed from the four triadic cases described below.

Triad 1: considering the service provider "MOTORSERV"

Triad T1 involves EBR, NATAIR and the service provider MOTORSERV. This firm is a maintenance and repair business unit belonging to a world-leading manufacturer of commercial and military jet aircraft engines and components. MOTORSERV provides maintenance and engine repair, components overhaul, engineering projects with technical support, and technical training. With an extensive global service network to support its activities, MOTORSERV has - as for all firms providing engine overhaul and repair services - some global competitors. Manufacturers thus benefit from privileged access to crucial technical information in relation to their own engines, which gives them an advantage, and has naturally led them to extend operations into the MRO (maintenance, repair and overhaul) field, and not only for their own products. Such is the case with MOTORSERV.

The Relationship between EBR and MOTORSERV began in 1996. Engine purchase is considered highly strategic. According to interviewee EBR 03, '*the choice of engine manufacturer is always made by the airline. We suggest the engine manufacturers we are used to working with and trust, but the airline makes the final decision'*. The engine is also the most expensive part of an aircraft. Indeed, although bundled in with the overall aircraft contract, it can in many ways be considered an independent purchase, along with associated services. Once selected, the core aircraft supplier/engine supplier/airline triad is established. In the case of NATAIR, MOTORSERV was selected, as it is a daughter company of the engine manufacturer TECH POWER and an official Maintenance, Repair and Overhaul (MRO) service provider – in accordance with the recommendations of EBR. The triad EBR – MOTORSERV- NATAIR began in 2009, when MOTORSERV started to lend in support of engineering projects and to provide technical assistance. Indeed, for the supply of aircraft to NATAIR Airlines, EBR has consequently developed an interactive interface with the engine supplier. Going beyond simple adaptations, the engine supplier has also simultaneously developed an interactive interface with the Airline, to facilitate development of specific technologies for the engine. This triad is one of those in the sample demonstrating the highest levels of interaction and commitment among all firms involved. '*We have an office of MOTORSERV inside our company. Close integration of all three partners EBR, NATAIR and MOTORSERV is essential for best results' (*NATAIR 02).

Triad 2: considering the service provider ONBOARDMEDIA

Triad T2 involves EBR, NATAIR and ONBOARDMEDIA, an on-board entertainment service provider. Its main contribution lies in an aircraft seat-back satellite television service, film programming and on-board wi-fi connectivity. The system also offers live flight trackers, enabling passengers to see where they are currently located during flight. The company is one of the four leading manufacturers in its field. In the relation between EBR and NATAIR, the service provider for on board entertainment services (ONBOARDMEDIA) is involved at

various stages: the aircraft production stage, as a supplier of hardware and software, and the stage following delivery of the aircraft (as the supplier of software). The triad EBR-NATAIR-ONBOARDMEDIA was established in 2012. This service provider was selected drawing on on the experience of the Chief Executive Office of NATAIR Airline with a previous airline, GreenJet, operating EBR aircraft in the US. Moreover, EBR had previously established relations with ONBOARDMEDIA. In fact ONBOARDMEDIA equipped EBR aircraft for other foreign airline customers, such as GreenJet Blue and LiAirline, for contracts handled by other EBR teams abroad. On this basis the manager of the NATAIR contract thus cited ONBOARDMEDIA as provider, completing the triad. Specific requirements of NATAIR related to the ability to broadcast TV programmes live during flight, as provided by ONBOARDMEDIA. Implementing this solution called for cooperation between ONBOARDMEDIA and EBR at the equipment installation stage, and subsequently during flight operation, for technical support. As confirmed by EBR02, '*ONBOARDMEDIA is a firm that already has relations with other airlines in the global market. The provision of in-flight TV programs offers competitive advantage for our customers, and consequently for ourselves in relation to serving our customers. Having ONBOARDMEDIA on-board as a new service supplier offers us an edge*'.

In other words, as on board services are not presently part of EBR's services portfolio, the service provider ONBOARDMEDIA is an important third party for future development in relation to customers. At present, as relationships in this triad were formed rather recently (approximately a year ago), inter-firm cooperation and activities within the triad are still at the developmental stage.

Triad 3: considering the service provider "OPSERV"

Triad T3 involves EBR, NATAIR and OPSERV, a maintenance and repair firm. OPSERV is a qualified service center proposed by EBR and performing a broad range of services in the commercial sector. The relationship between the dyad EBR and OPSERV began in 2010, when OPSERV became a qualified centre. EBR respondents explained that OPSERV – a national firm -was considered an excellent maintenance and repair service provider, and that they had been working together for 40 years prior to OPSERV being bought out by a foreign group. OPSERV had already served the customer NATAIR before, but relations intensified after qualification of OPSERV by EBR. This qualification in 2010 marked the emergence of the OPSERV-EBR-NATAIR triad.

The respondents indicated that the development of the long term relationship between OPSERV and NATAIR brought with it advantages in terms of price and speed of service delivery. EBR, the manufacturer, plays an important role in technical guidance and continuous improvements to aircraft. To facilitate this, resource exchange occurs via frequent interaction. There are dedicated teams and representatives of all three companies working together. A representative of EBR, for example, spends two days a week at NATAIR's offices. At the same time an NATAIR team works together with the OPSERV team to monitor service provision. When asked about the state of the triad, managers described the relations between all parties as close and intense with frequent interaction. Managers of both EBR and OPSERV compared the relationship to a 'marriage',and used the word'familiarity' to describe the advantages of their long-term relationship: '*For me, it looks like a marriage*' (OPSERV01). The relationship between OPSERV and NATAIR also demonstrated high levels of interaction and familiarity. Mutual trust and commitment, and co-creation of value were terms used to describe the relationships between these three companies.

Triad 4: considering the service provider "AFTERPARTS"

Triad T4 involves EBR, NATAIR and the service provider AFTERPARTS, a leading provider of aviation parts and services. AFTERPARTS describes itself as a provider of a portfolio of solutions that address the industry's logistics, warehousing, program management, and sourcing needs, offering services related to repair management, asset management and distribution. Business relationships between AFTERPARTS and EBR began in 2008. AFTERPARTS is considered by EBR respondents as a strategic supplier.

Since start-up of the triad, close collaboration and intensive exchange has taken place, involving all three parties. An AFTERPARTS representative works in the offices of EBR to cater for all coordination issues regarding all customers the two companies have in common. In particular, for this triad, given the strategic importance of NATAIR to EBR, especially close cooperation takes place to ensure services provided via the 'Pool Spare Parts Program'. The result is a particularly high level of interdependence between the three parties. In the words of AFTERPARTS: '*Because we depend on EBR to have access to customers... but also because we are service providers to the EBR program, I believe that EBR has more power in this relationship'* (AFTERPARTS01). EBR sees the situation as being more balanced: *'We are unable to offer all this distribution by ourselves. AFTERPARTS help us with this service for our customers and also with other aftermarket services. It's a win-win relation overall and particularly important for the success of our dealings with NATAIR'* (EBR04).

NATAIR supports this analysis, declaring: *'We need both the aircraft from the manufacturer and the services related to it. In fact AFTERPARTS is one conditioning factor for having chosen EBR in the first place. It makes for a perfect threesome'* (NATAIR04). Therefore a close triadic set-up, involving all parties**,** applies for all services covered by the Pool Program. However, other services outside the scope of the Pool Program can be offered by AFTERPARTS and invoiced direct to NATAIR, without involving EBR.

Inter-triad links

To complete our description of the individual cases described above, it is useful to understand the context in which these triads evolve, and the links between them, as described by the interviewees. Thus, by way of illustration of these links, OPSERV, for example, being a provider of maintenance and repair services, can be seen to play an important linking role across triads. As mentioned by the interviewee MOTORSERV 01, '*the engine is a strategic component. We are sometimes called upon to provide service on OPSERV's premises. We thus, at the same time, work in close conjunction with them to ensure continuous improvements'*. Moreover, manager ONBOARDMEDIA 01 back this up by saying *'the role of OPSERV was crucial in the process of changing aircraft for installation of ONBOARDMEDIA on board. As many aircraft are in operation, we needed to ground them to make the changes. OPSERV is very important to this process'*, (ONBOARDMEDIA 01). The same logic applies for Triad 4 (EBR-NATAIR-AFTERPARTS) and OPSERV. AFTERPARTS, *'as a distributor of the Pool Program, help us in order to reduce time. The faster we are, the better for NATAIR'*, affirms manager OPSERV01.The triads can thus be seen, in virtually all cases, to demonstrate interlinkages, and indeed some kind of interdependency.

Thus, considering the pre-contract and post-contract phases in aerospace industry (Ferreira et al, 2014), we can understand the development of relationships among these firms over time. For a better illustration, Table 2 attempts to illustrate which firms interact in each phase and the solution related to each one:

Table 2 - Phases of the relationship between EBR and NATAIR and the provision of solutions

CASE ANALYSIS AND DISCUSSION

The data brings to light the fact that the provision of solutions between EBR and NATAIR is not linear or static. As described in Table 2, different phases of the relationship can be identified with different customer expectations for solutions, mainly as pre-contract and post-contract phases (Tuli *et al.,* 2007; Sawhney, 2006). In the aerospace industry, as a pre-contract phase, the Model Choice and Commitment Phase can be identified. After the initial business contract signed, the relationship between the Customer and the Manufacturing firm is developed through three different stages: the Joint Definition Phase; the Manufacturing Phase and the Delivery/Operation Phase (Ferreira et al, 2014). In the Model Choice and Commitment Phase, the customer requires the knowledge about the manufacturer portfolio for products and services, considering its ability to support and develop the aircraft over time. At this stage in the relationship, we can identify "promises for solutions" based on the manufacturer's previous provision of solutions for other customers. These pre-contractual "promises for solutions" will guide the development of the initial business contract between the customer and the manufacturing firm, in which the requirements for products and services to be provided are established .

In the Joint Definition Phase (up to one year), the Customer requires from the Manufacturer the ability to design the model that was chosen. At this stage, the provision of solutions is related to the planning process and to the development of strategic partnerships with suppliers, in order to guarantee an aircraft model that can fit customer needs.

In the Manufacturing Phase, however, the customer requires the coordination of integrated teams related to the production process, as well as the provision of tangible items, such as components. Solutions at this phase are related to the capacity/ability of the manufacturing firm to produce the aircraft (as a tangible good), and alsoto the services related to this process. Nevertheless, after the delivery of the aircraft, the longest stage of the relationship (up to 25 years) between the manufacturing firm and the customer commences. Solutions over this period are related both to the fleetperformance (such as maintenance, repair, training and new services for innovation), and to the improvement of the aircraftby technological upgrades. For this, the manufacturing firm, the customer and other partners, as suppliers of goods and services, establish relations in order to obtain value creation, reducing costs and/or developing unique competitive advantages.

The provision of solutionsin this "Delivery/Operation"Phase depends on the development of partnerships over time. In order to fulfil the initial business contract, the manufacturing firm, as a system integrator, tries to indicate to the Customer some qualified suppliers. Relationships are established and increased levels of interaction can be developed as soon as firms understand that they can obtain value working together. For market reasons, some partnerships can be dissolved and relations can be developed with another partner. In the "Delivery/Operation" Phase, the provision of a solution can not only remain related to achievingissues described in the initial business contract, but can also be extended to new processes of business related to innovations ofproducts/services for high levels of value co-creation, in a dynamic process.

As described in Table 2, in each phase of the relationship, different service providers are involved, not only as triads, but also as a conjunction of inter-linked relations, as described above. The provision of solutions between EBR and NATAIR is dynamic and depends on the relationship with other actors in the business network. The idea of a "promised solution" in a

pre-contract phaseis presented here in order to show that the “effective solution” can only be developed in the “real” contextof interaction among partners - i.e. firms establish products and services dimensionsin business contracts, but it is only the dynamic of the network that enables firms to combine them as solutions over time. Thus, considering the Aerospace Industry as a complex engineering service system and the phases of relationship between the customer and the manufacturing firm, the analysis of the data enables us to come up with a description of categories of solutions, as presented below.

Developing a framework: categories of business solutions in complex engineering service systems

As long-term relationships are developed in the aerospace industry, we can identifyfour categories of solutions in complex engineering service systems: 1) solutions before manufacturing; 2) solutions related to manufacturing; 3) solutions for product performance and 4) solutions for innovation, as illustrated in Figure 2:

Figure 2 - Categories of solutions in a complex engineering service system

These categories attempt to describe the way that, in each phase, the customer can require some different combinations of products and services, as well as capacities, knowledge and abilities. Before manufacturing, (a phase that can last up to ayear), the customer requires issues related to the design of the fleet to be resolved. In this phase, the Customer waits for solutions related to the design of the best fleet, in order to reach its market with the most appropriateaircraft. Next, in the Manufacturing Phase, the solution is more related to the process of production, i.e. involving tangible goods and services related to the Manufacturing Phase.The deadline needs to be met and the Manufacturer needs to be able to produce and/or access resources, orchestrating the system for the production.

On other hand, when the aircraft is delivered, the role of the Manufacturer as a system integrator is more related to the performance of the fleet. Products (such as spare parts or components) and services (maintenance, repair, and training) are combined in order to guarantee what was agreed by the initial business contract with the Customer. In this phase, we can observe that customers require solutions that will provide the best performance of the fleet. As this is the longest phase, relationships concerning the provision of solutions related to performance of the product can be developed over a long period of time. However, if firms perceive that they can work togetherfor the development of new services and/or products, a new category of “Solutionfor Innovation” may be required. In this phase, firms can develop more integrated activities in order to create new market opportunities or competitive advantages. Products and services can be developed as new technologies, establishing high levels of interactions and interchange of resources among partners. In sum,Table3 shows how, in the same relationshipover time, the customer can require different combinations of products and services that are co-created with the manufacturing firm and other network partners:

Table 3 –Categories of solutions in a complex engineering service system

FINAL CONSIDERATIONS

With reference to the Aerospace Industry, this paper presents the results of empirical research to purpose a typology for business solutions as a market shaping process, taking complex engineering service systems as the context of analysis. Developed by means of a case study approach, the data shows that solutions are provided in a relational and networked

process. The combination of products and services required by the customer can change according to different phases of the relationship with the manufacturing firm. The inter-linked relations developed between EBR, NATAIR and the four service providers shows that business solutions can be understood not as the result of a linear process, but, on the contrary, as a result ofthe market and its evolution, or as a market scripting (Spencer and Cova, 2012; Storbacka and Nenonen, 2011).

As long-term service contracts to support complex engineering products are becoming the norm (Ng et al, 2011), the phases of the relationship between the Customer and the Manufacturing firm in this study reveal four different categories of solutions provided over time in complex engineering service systems: 1) solutions before manufacturing; 2) solutions related to manufacturing; 3) solutions for product performance and 4) solutions for innovation. As a system integrator, the manufacturer needs to guarantee the provision of goods/services throughout the life cycle of the product. As the relationship evolves, different combinations of products and services are required, being provided with the customer and other partners over time.

This understanding about categories of solutions related to each phase of the relationship has academic and managerial implications. As business solutions can vary over different phases of the relationship, the provision of solutions requires some strategies related to innovation. As shown, it is in fact only through the development of the relationships with the customer and the partners that the provision of solutions occurs over time. In other words, this dynamic requires the continuous management of the relationships to guarantee higher levels of value co-creation. Market changes, new competitors, new technologies, economic policies and other external factors can influence the way that relationships and also the provision of solutions among firms are developed. The concept of “promises of solutions” presented at a pre-contractual stage highlights the idea that initial business contracts are developed based on reputation and credibility. However, as a market scripting process, the provision of solutions requires value-in-use (Ng et al, 2011; Payne et al, 2008; Prahalad & Ramaswamy, 2003) and hence dynamic processes of relationships among partners.

This study also highlights the fact that moving to a service-oriented approach means that manufacturing firms need to consider the servitization as a market-based process. In order to provide solutions, manufacturing firms need to offer services to support and develop the product, depending on market relationships. New studies can be developed for a detailed description as regards servitization, in this context, as a market scripting process.

As providing solutions is a dynamic process, it is interesting to highlight the fact that this case, as described above,is related to customer´s purchase of a first fleet. However, new aircraft can be ordered, with different stages of the relationship being developed simultaneously. The greater the knowledge and involvement between the two firms, the more varied are thecombinations of products and services that can be developed at each stage. In the case of new orders, the relations established for the first purchase may influence the provision of solutions in the repurchase, resulting in a different combination of products, services, people, equipment etc.

As limits to the research, we can identify**:** firstly, that the data collected relates to a set of triads all located within the same national boundaries; secondly, the majority of the triads are recently formed, and thus observation of the relationship dynamics is limited. As a next step, further research into the inter-relationships in a solution business context can consider the four categories identified here by means of a quantitative methodology, in order to verify generalizations.

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TABLE 1

Table 1 - Firms investigated and characteristics of interviews

CODE FOR INTERVIEWEES	INTERVIEWEE'S FUNCTION	INTERVIEWS/DURATION
AIRCRAFT MANUFACTURER		
FIRM: EBR		
Interviewee EBR 01	Technical Coordinator. Engineering Specialization Program.	1x 3 hours + 1x 2 hours of face-to-face interviews
Interviewee EBR 02	Manager, Customer Support and Services Development.	1x 2 hours + 1x 2 hours of face-to-face interviews
Interviewee EBR 03	Senior Manager, Systems Engineering	1x 2 hours face-to-face interview
Interviewee EBR 04	MRO Services Engineer	1x 1 hour face-to-face interview
Interviewee EBR 05	MRO Services Engineer	1x 1 hour face-to-face interview
CUSTOMER FIRM		
FIRM: NATAIR (Airline in commercial area)		
Interviewee NATAIR 01	Chief Operating Officer	1x 1 hour face-to-face interview
Interviewee NATAIR 02	Maintenance Director	1x 2 hours + 1 x 2 hours of face-to-face interviews
Interviewee NATAIR 03	Maintenance Planning Manager	1x 3 hour face-to-face interview
Interviewee NATAIR 04	Technical Coordinator	1x 1 hour face-to-face interview
Interviewee NATAIR 05	Technical Engineer	1x 1 hour face-to-face interview
SERVICE PROVIDERS		
FIRM 1): MOTORSERV (maintenance and repair services of aircraft engines):		
Interviewee MOTORSERV 01	Senior Sales Manager	Response to the questionnaire via email + approx. 30 minutes telephone interview
FIRM 2): ONBOARDMEDIA (On board services):		
Interviewee ONBOARDMEDIA 01	Business Development Manager	1x2 hour face-to-face interview + approx. 30 minutes telephone interview
FIRM 3): OPSERV (maintenance and repair services):		
Interviewee OPSERV 01	Sales Manager	1x 2 hours face-to-face interview
FIRM 4): AFTERPARTS (Aftermarket services):		
Interviewee AFTERPARTS 01		1x 2 hours face-to-face interview + approx. 30 minutes telephone interview

FIGURE 1

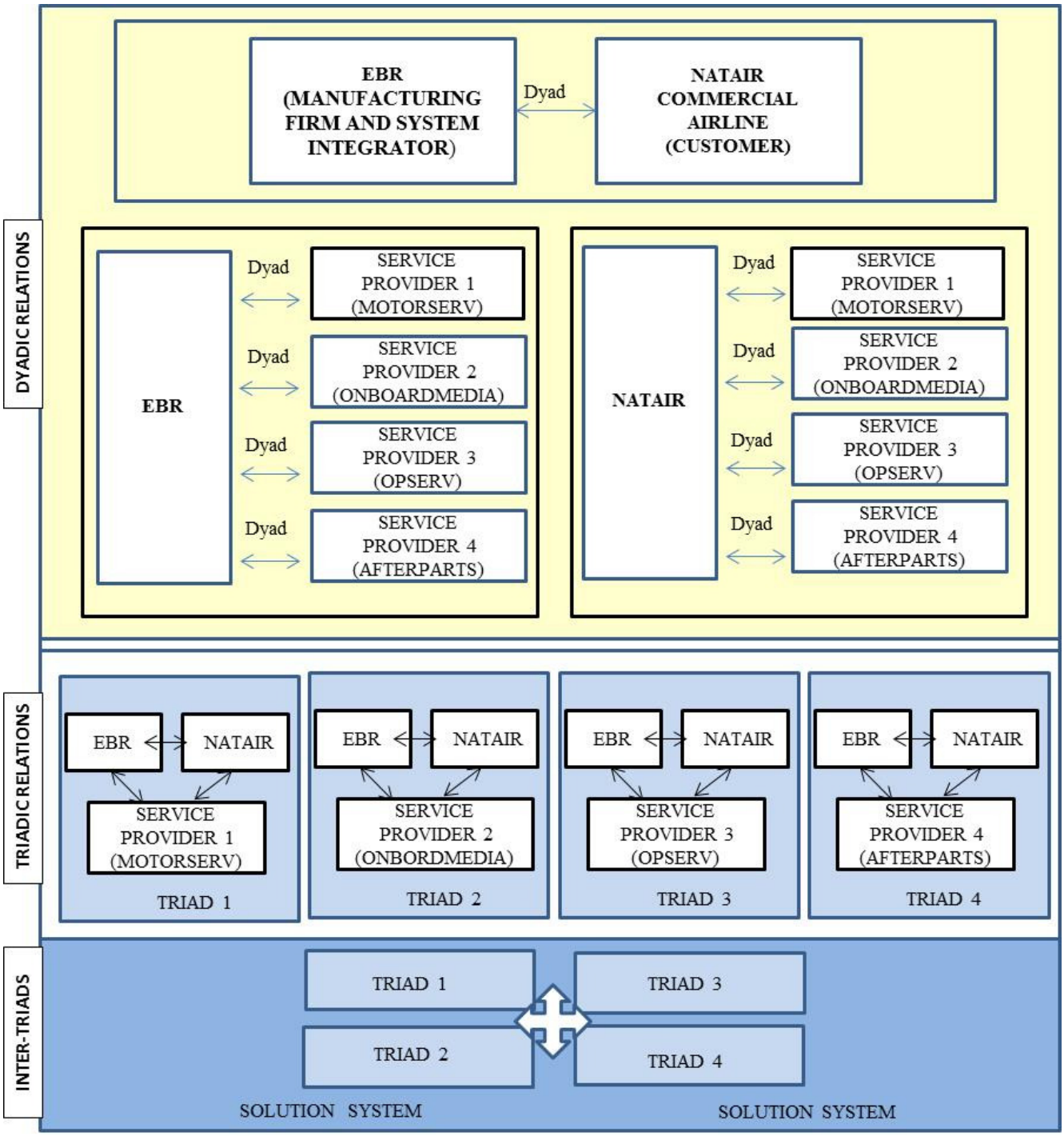

Figure 1 – Dyads and triads developed by six firms as part of a solution system

TABLE 2

PRE-CONTRACT	**POST-CONTRACT**		
MODEL CHOICE AND COMMITMENT (Matching) (Combining)	**JOINT DEFINITION (Contracting and/or (Mixing)**	**MANUFACTURING (Mixing) (Sharing)**	**DELIVERY/ OPERATION (Mixing) (Sharing)**
Duration of the phase: Variable	**Duration of the phase:** Up to one year	**Duration of the phase:** From one to five years	**Duration of the phase:** Aircraft life cycle (20 to 25 years)
Main dyad on this stage: EBR and NATAIR (highlighting that the customer NATAIR consider in this stage the EBR's network related to the provision of solutions over time)	***Triads on this stage:*** Triad 1) EBR, NATAIR and POWERTECH/ MOTORSERV Triad 2) EBR, NATAIR and ONBOARDMEDIA	***Triads on this stage:*** Triad 1) EBR, NATAIR and POWERTECH/ MOTORSERV Triad 2) EBR, NATAIR and ONBOARDMEDIA	*Triads on this stage:* Triad 1) EBR, NATAIR and MOTORSERV Triad 2) EBR, NATAIR and ONBOARDMEDIA Triad 3) EBR, NATAIR and OPSERV Triad 4) EBR, NATAIR and AFTERPARTS
No triads developed yet	***Inter-triadic links in this stage:*** EBR, NATAIR and MOTORSERV + OPSERV	***Inter-triadic links in this stage:*** EBR, NATAIR and ONBOARDMEDIA + OPSERV EBR, NATAIR and MOTORSERV + OPSERV	***Inter-triadic links in this stage:*** EBR, NATAIR MOTORSERV + OPSERV ---------- EBR, NATAIR,AFTERPARTS+ OPSERV ---------- EBR, NATAIR and ONBOARDMEDIA + OPSERV
Evidences of Solutions as a Market Shaping Process: -Provisional system integration (by EBR) and initial offering/needs fit.	**Evidences of Solutions as a Market Shaping Process:** -Advanced design integration and adaptation to requirements - Capacity to develop integrated teams with the customer.	**Evidences of Solutions as a Market Shaping Process:** - The provision of a customized aircraft - Continuous design innovation and adaptation to environmental shift prior to delivery.	**Evidences of Solutions as a Market Shaping Process:** - Provision of spare parts and services related to maintenance and repair; -Post-delivery system problem solving and technology upgrades - New services to reduce costs and/or to reach competitive advantage.

FIGURE 2

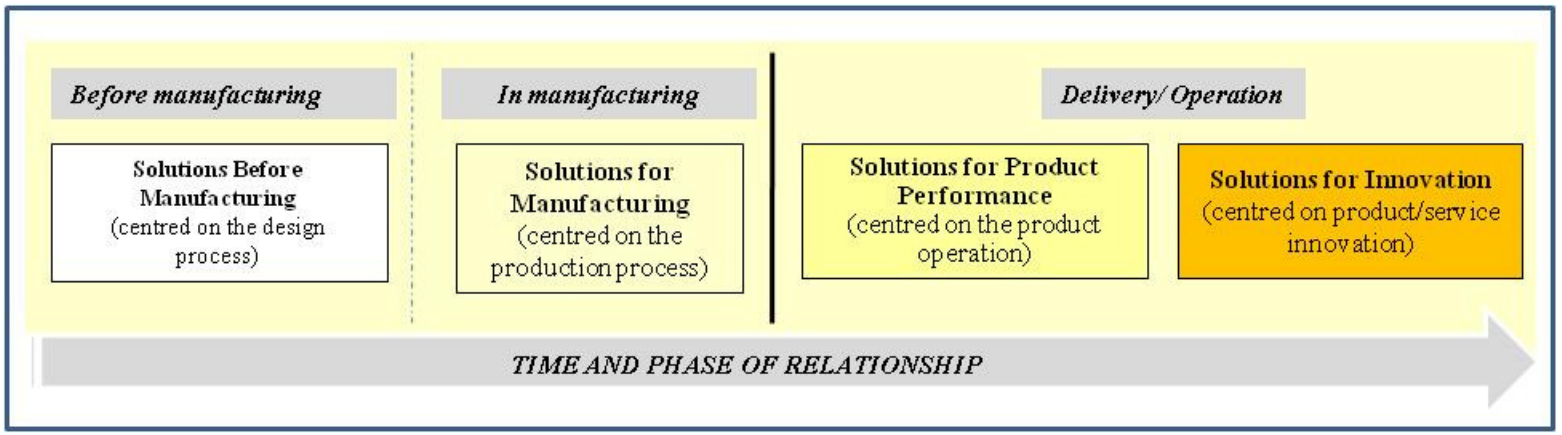

Figure 2 - Different requirement for solutions over time

TABLE 3

	CHARACTERISTIC OF SOLUTIONS TO EACH CATEGORY					
CATEGORIES	**MAIN FOCUS**	**Product**	**Service**	**People**	**Material/equipment**	**Information**
1) SOLUTION BEFORE MANUFACTURING	The provision of solution is based on the design of the product.	In development.	Related to design. Ability to articulation of partners. Customization.	Integrated teams with suppliers directly involved in designing.	Hardware, software, systems for designing.	Technical expertise for designing. The Manufacturing firm reputation.
2) SOLUTION RELATED TO MANUFACTURING	The provision of solution is centred on the production process. Manufacturing firm can be able to produce and/or access tangible resources and services related to production.	Components and other material used in manufacturing.	Related to manufacturing. Ability to articulation of partners.	Integrated teams with suppliers directly involved with manufacturing.	Hardware, software, systems for manufacturing.	Know how for manufacturing. Knowledge about the market, competitors, changes in prices etc.
3) SOLUTION FOR PRODUCT PERFORMANCE	Solution centred on the product performance. Services are required to support and develop the product over time.	Aircraft. Components and spare parts.	Maintenence and repair, trainning and other services to guarantee a better performance.	Integrated teams with suppliers directed involved with supporting.	Hardware, software, systems to support products and services.	Know how for supporting. Knowledge about the market, competitors, changes in prices etc.
4) SOLUTION FOR INNOVATION	Solution centered on the innovation of products and/or services;	Aircraft. Components and spare parts. New products and technologies.	Maintenence and repair, trainning and other services to guarantee a better performance. Development of new services for differentiation.	Integrated teams with suppliers directed involved with process of innovation.	Hardware, software, systems to support products and services and innovation.	Know how for innovation. Knowledge about the market, competitors, changes.

Table 3 –Categories of solutions in complex engineering service systems