

---

## From 'aircraft manufacturer' to 'architect-integrator': Airbus's industrial organisation model

---

Med Kechidi

University of Toulouse,  
LEREPS, 21, allée de Brienne,  
Manufacture des Tabacs,  
31042 Toulouse, France  
E-mail: kechidi@univ-tlse1.fr

**Abstract:** The aim of this article is to show that Airbus's success can be attributed to two types of factors. First, each new aircraft model has produced a technological breakthrough in the design and manufacturing of aircraft. Secondly, Airbus's capacity to evolve their industrial organisation model in keeping with the technological transformations. In this trajectory, modularisation and outsourcing policies have played major roles. In particular, they play a major role in the emergence of new actors the pivot-firms. These firms have a critical position in management of technical and organisational interfaces between the architect-integrator and the firms participating in the design and production of aircrafts.

**Keywords:** Airbus; industrial organisation; innovation; modularisation; outsourcing; pivot-firm.

**Reference** to this paper should be made as follows: Kechidi, M. (2013) 'From 'aircraft manufacturer' to 'architect-integrator': Airbus's industrial organisation model', *Int. J. Technology and Globalisation*, Vol. 7, Nos. 1/2, pp.8–22.

**Biographical notes:** Med Kechidi is an Associate Professor in Management at the University of Toulouse 2, Le Mirail. He is also researcher at LEREPS, research centre of University of Toulouse 1 Le Capitole. His areas of research include organisational change, innovation, governance, inter-organisational relations and supply chain management in particular in aeronautics.

---

### 1 Introduction

In April 2005, the A380 took off from Toulouse as the biggest jumbo jet ever built by mankind. That flight was another step in the long history of the contribution of the French industry to global aeronautics, which dates back to 1890 when Clement Ader invented the word 'avion' to qualify a flying vehicle propelled by an engine. Ever since 2005, Airbus has become the market leader in civil aeronautics, both in terms of deliveries and in terms of aircraft orders. What are the keys factors in the success of this firm that was born in the 1970s?

Clearly, these factors are diverse in origin. However, a certain amount of research attributes Airbus's competitive advantage to the quality of the organisation and management of their supply chain. For example, for Rose-Anderssen et al. (2009), the

evolution of the different forms of organisation of the aeronautical supply chain is an efficient response to the evolution of markets and competitors. Similarly, Nolan and Zhang (2002) argue that modern aircraft have become so complex that the competitive advantage resides in the capacity of aircraft manufacturers to coordinate the supply chain and to integrate the various components of the aircraft. According to Cagliano et al. (2004) or Ehret and Cooke (2010), it is in fact the rationalisation of the production process as a whole that accounts for Airbus's performance. For other authors (Rose-Anderssen et al., 2009), an evolutionary approach shows that it is the risk-sharing partnerships that are at the origin of the creativity and innovation involved in the aircraft production process.

The point in common between all these explanations of Airbus's competitive advantage is the leading role they attribute to the dynamics of innovation in a complex product industry. Their other similarity is that they mostly look at what is occurring 'outside' the firm, and they do not relate technical innovation to organisational innovation.

Airbus is the leader of the market since 2003 in terms of sales. With more than 1,000 orders in 2011 (370 for Boeing) it is an undisputed market actor. A large part of this performance can be explained by the industrial organisation model adopted. The aim of this article is to focus on two types of factors. First, each new aircraft model has produced a technological breakthrough in the design and manufacturing of aircraft. Secondly, Airbus's capacity to evolve their industrial organisation model in keeping with the technological transformations. Without indulging in excessive technological determinism, it can be said that the successive adoption of technologies has generated profound modifications in the industrial organisation of the aircraft manufacturer. They have also completely reconfigured the relationships between the different participants in the aircraft manufacturing process. More precisely, the positive relationship between technological choices and organisational forms is concretely observable through Airbus's programmes. Airbus's technological expansion can be construed as, for each new programme, a break with the old technological paradigm as well as the adoption of a new organisation of production. According to us, it is this technological and organisational dynamic that contributes substantially to the commercial success of Airbus.

Two factors seem to us to be crucial in this organisational model and its evolution: firstly, high modularisation and its corollary, high integration of aeronautical systems, and secondly, the politics of refocusing and outsourcing. These characteristics are admittedly shared by other manufacturers, but, according to us, they are more pronounced in Airbus's case. Today, the reinforcement of these mutations announces the emergence of a new industrial organisational model: 'aircraft manufacturers' are progressively becoming 'architect-integrators' of aeronautical systems (Cagli et al., 2009). It is this historical, technical and organisational trajectory which we will analyse.

The main idea underlying this analysis is that there are positive correlations between technology (and innovation) and the organisational forms that produce complex products. More generally, our basic hypothesis is that technological changes require organisational set-ups that are compatible with the nature of these changes. Therefore, we feel it is relevant to approach these issues from the point of view of the industrial model and inter-firm relations.

There will be three stages to our analysis. First, we will present the spatial distribution model of Airbus's activities between the different actors (countries) that participate in aircraft manufacturing. We will note that, from its origin, the organisational model is

widely spatially distributed between different production sites and different players. We will also see that the division of labour between the different partners (German, French, and British) has changed very little over time. Then, we will analyse the technological trajectory of the different programmes. We will see that the technological breakthroughs successively introduced by each new aircraft have consequences on the organisational model of the firm. Finally, we will look at the modularisation and the integration of systems. We will see that a reinforcement of these two characteristics of aircraft manufacturing leads to a pronounced redistribution of the roles of the firms involved in the aircraft manufacturing process. This redistribution manifests itself by the emergence and development of pivot firms.

## **2 The spatial organisational model of Airbus activities**

Several theoretical and empirical frameworks account for the clustering and anchoring factors in aeronautics (Agrawal and Cockburn, 2003; Cooke and Ehret, 2009; Niosi and Zhegu, 2010; Kechidi and Talbot, 2010). In the case of Airbus, the industrial organisation is based on a division of labour at national, European and international levels founded on the main abilities of each production site (Kechidi, 1996; Talbot, 2000). The production cycle of an Airbus is done within the boundaries of a quadruple division of labour:

- A European division of labour between the four national companies that are involved in EADS, UK, Spain, Germany and France. There are in Europe 16 sites of production which participate directly at division of work.
- A national distribution of labour orchestrated by the national company. In the case of Airbus France, production is divided among four production sites (Toulouse, Nantes, Méaulte, Saint-Nazaire).
- A dispatching of tasks among the different plants within the same site. For instance, for the Toulouse site, tasks are divided among the four plants of the site (Blagnac, Colomiers, Saint-Martin du Touch and Saint-Eloi).
- A division of labour between Airbus and a vast network of subcontracting firms located in France and abroad.

For the distribution of the workload on a European level, the most common organisation is to build the wings in the UK, the tail units in Spain, the fuselage in Germany and the cockpit and the central section of the fuselage in France. The final assembly is done either in Toulouse or in Hamburg. The specialisation per site is shown in Table 1.

Nevertheless, that specialisation is not perfectly transverse to all the programmes. Indeed, depending on the model of the plane, the division of labour may vary. Thus, the wings of the A300, A310, A330 and A340 that are made in Broughton are first routed to Bremen in order to add equipment before being redirected to Toulouse where they are assembled, while the wings of the A380 do not transit through Germany. The A320s are assembled in Toulouse while the other planes of that family (the A318, A319 and A321) are assembled in Hamburg. This duplication of the assembly sites reflects the regular resurgence of the confrontations between the European industrial partners, the German partner wanting to take care of the very symbolic act of doing the final assembly of some Airbus aircraft, for national prestige reasons but also because the teams based in

Hamburg master the technical and organisational skills needed for such tasks. The announcement made in 2007 that a third final assembly line for the A320 was being reopened in Hamburg illustrates the weight and the pregnancy of political imperatives in the industrial decision-making process. These decisions, including ones regarding localisation and choice of managers, must always take into account the existence of a French-German equality pact, which is a reason behind the success but also behind some of the difficulties that the European manufacturer has faced.

**Table 1** Specialisation of the main production sites of Airbus SAS

<i>Airbus Deutschland</i>	
Bremen	Elements of the fuselage rear section
Dresde	Production and assembly of the airplane floors
Hambourg	Pressurisation systems Air conditioning Assembly of fuselage rear section Final assembly of the A318, A319, A321
Laupheim and Buxtehude	Customisation
Nordenham	Machining large mechanical parts
Stade	Production of the drifts and of the vertical tail units
Varel	Processing of the high precision pieces of the fuselage
<i>Airbus España</i>	
Getafe	Production of the signs in composite materials Design and final assembly of the horizontal tail units
Illescas	Production of carbon fibre raw signs for the horizontal tail units
Puerto Real	Assembly and manufacturing of the carbon fibre components or of the alumina equipments for the horizontal tail units
<i>Airbus France</i>	
Méaulte	Manufacturing of the mechanical nose cone pieces
Nantes	Assembly of mechanical and composite sections Centre box
Saint-Nazaire	Assembly of sections of the central fuselage
Toulouse	Avionics design Design and production of the engine pylons Assembly of the A300/310, A320, A330/340, A380 Flight tests
<i>Airbus UK</i>	
Bristol-Filton	Wing design Equipments of the electric systems of the wings on the A320 Part of the fuselage of the A321 Pieces for the wings of the A330/340
Broughton-Chester	Production and assembly of the wings

Like a giant puzzle that needs to be put together, the assembly of an Airbus generates numerous inter-sites flows. Even if they introduce a more functional organisation and a stronger horizontal integration, the current reorganisations do not fundamentally question the current distribution of industrial tasks, at least on a mid-term basis. The expected configuration over the next few years is most probably the end of the industrial duplications with a specialisation of the Toulouse and Hamburg assembly sites depending on the planes: in Toulouse the long haul aircraft and jumbo jets (A330-340, A380 and A350) and in Hamburg the A320 and its future successor. However, the impact is very noticeable when it comes to the nature, the density and the content of the relationships between Airbus and the firms that participate directly or indirectly to the construction of the aircraft. That impact seems to generate the industrial and organisational conditions necessary to create a new organisational model of aeronautical activities. Before underlying its main characteristics, let us take a look at the evolution of the main programmes, since it seems to us that the trajectory of innovation and of the industrial model is linked with the technical and organisational trajectories. These trajectories illustrate the industrial evolution of Airbus and the affirmation of market logic (Frigant et al., 2006). This market logic replaced, during the '80s, an arsenal logic in which public intervention was very strong (Muller, 1989). While an aircraft used to be considered successful it is was technically impressive, a good aircraft is now an aircraft that sells. From a symbolic standpoint, we have gone from a technical success but a commercial failure (Concorde) to a commercial and technical success (Airbus).

### **3 The innovation processes: 'all up front', 'all electric', 'all composite'**

In order to understand what is happening nowadays in this sector, it is necessary to take into account the background of technological innovations that have marked the evolution of the Airbus programmes. At every stage, these innovations have constituted a paradigm break in the sense that they introduced innovations and new product architectures. Without indulging in excessive technological determinism, it can be said that the successive adoption of technologies has generated profound modifications in the industrial organisation of the aircraft manufacturer but also in its relationships with the subcontracting firms. If the increase in complexity in aeronautics is nowadays mainly observed in avionics and embedded systems, it can also be found in the whole design and production of the aircraft from the beginning of the first programmes.

The A300 was the first long-range twin-engine jet with a large fuselage. It also unveiled the 'all up front' control cabin. This innovation enabled two-man aircraft handling and introduced a new approach in the design of the product. The A300 started the 'a good aircraft is an aircraft that sells' era. In terms of the outsourcing process, during this phase Airbus manufactured most of the aircraft components internally. It was a classical subcontracting situation where firms functioned as external workshops supplying components according to the detailed design provided by the manufacturer.

In 1984, the introduction on the A320 of fly-by-wire control as well as a new cockpit design generated an authentic revolution in that area. Electrical control and auto flight unveiled the era of the mass arrival of electronics and embedded systems. In this case as well, this had an effect on Airbus's industrial organisation. The whole architecture of the airplane was partially revisited. The mastery of electrical systems became a fundamental specific asset.

In 1987, the A318/A319/A320/A321 and A330/A340 families introduced a quasi standardisation of the cockpit equipments. Aircraft belonging to the same family came to have the same instrument panel, the same attitude control procedures, the same avionics and almost the same systems. These similar configurations allowed the same crew to fly all the aircraft belonging to one family. Maintenance and operating costs were also reduced.

The technological breakthroughs made with the A380 were notably innovations linked with the size of the airplane and integrated modular avionics (IMA). The size and the weight of the airplane have required the development of electric and hydraulic sub-systems for transporting energy that do not generate large weights nor important head pressure losses. The A380 sped up the era of the 'all electronic airplane'. This concept replaced the hydraulic central systems that are linked through complex circuits by electro-hydraulic systems that are dedicated to each piece of equipment. This innovation enabled important weight gains and a reduction of the production and maintenance costs.

The other innovation introduced in the A380 was the integrated modular electronic. Until the A380 programme, the avionics systems were made of a range of linked numerical devices (calculators), each dedicated to only one function. Because this meant a multiplication of devices, it generated massive loads and costs. The IMA adopted by the A380 (and by the B777 and 787) meant abandoning that principle of a dedicated resource in order to use one architecture for different applications. This electronic organisation favoured a large upgradability of the software functionalities since it allowed for elements to be changed without needing to change the computer science architecture of the aircraft.

If there was a major change with the introduction of more electric technologies in aircraft, "the integration of systems and the standardization of avionics could represent a much bigger change, which would allow a better management of the fleets within the companies and a better valuation of them".<sup>1</sup>

The benefits of this kind of technology are clear. These are typically technologies that improve the performances of the aircraft while reducing the manufacturing and maintenance costs as well as the weight of the planes. From an industrial standpoint, going from the 'one calculator for each function' logic to a 'one calculator for various functions' logic reduces the number of stakeholders in the manufacturing of the electronic modules and allows the delegation of the coordination function to a sole actor, a pivot-firm, that will have to organise the subcontracting tasks.

Although the A350 adopts technologies that have already been tested on previous programmes, among others the A380 and the A400M, it pushed further the 'all electric' and 'all composite' concepts. The percentage of composite materials thus went up to 52% compared to 38% on the aborted version of the A350, while the amount of aluminium and lithium stayed at 20%. This evolution toward composite materials was another vehicle of the mutations that affected the aircraft manufacturer and their partners. The presence of composite materials in the Airbus programmes has not ceased to increase since the A300. Thus, while the level of composite equipment was of 5% on the A300–600, it reached 25% on the A380. On the A380, composite materials appear in the centre box, a major piece, as well as on the tail section and tail cone, on the pressure bulkhead, on the beam of the upper deck and on the structures of the wings. In fact, the A350 is the aircraft that appears to be the major vehicle of the turn towards composite materials.<sup>2</sup>

This brief 'technical history' of the successive Airbus programmes clearly shows that the deployment of each new aircraft model was accompanied with important technical

innovations. This seems to illustrate Lawrence and Thornton's (2005) point that the success of an aircraft depends crucially on its novel characteristics in comparison with competitor's models.

Clearly, the 'New Airbus' announced by Power 8 Plan in 2007 aims to refocus the activities on the core competencies of the firm. These competencies are at the heart of the profession of aircraft manufacturer and include the design of the global architecture of the aircraft and the cabin, the integration of systems, the assembly of components and the customisation and testing of equipment. Other activities, that involved technology that is completely mastered or common, are outsourced. By strengthening its status as an architect-assembler, Airbus positions itself upward and downstream of the value chain. All the activities that are considered strategic from the technological, industrial and market standpoints are undertaken internally. This trend translates into an important increase in outsourcing non-strategic activities. This outsourcing is thus based on the creation around the firm of a stable network of partners with complementary activities in which lasting relationships are contracted and partnership links are created with the objective of improving performance while sharing risk.

The observed trend, particularly in the last few years, shows an increasing focus on Airbus's core business and an emphasis on outsourcing policy<sup>3</sup>. More than this, it demonstrates a real transformation in the status of aircraft manufacturers. Airbus and Boeing and other aircraft manufacturers radically changed their way of building and developing new aircraft (Amesse et al., 2001; Destefani, 2004; Kechidi, 2006; Cagli et al., 2009). In the past, aircraft manufacturers designed, conceived and built their planes mainly internally. Nowadays, they increasingly defer the design and production of whole sections to partners. Therefore, they go from being an 'aeronautics manufacturer' to being an 'architect-integrator of aeronautics systems'. In the context of this evolution, the modularisation of aeronautical systems has played a central role.

#### **4 Modularity: technical, organisational and cognitive dimensions**

The literature on modularity is based on Simon's (1962) theories on the decomposability of complex systems. This conception of modularity, called modularity of the product or technical modularity (Ulrich, 1995; Cohendet et al., 2005) is firstly a tool aimed at reducing complexity. "Modular architecture proves to greatly reduce the complexity of the complex systems by proposing a decomposition into autonomous subsystems, as it is possible to develop and pre-assemble them separately, linked on to another by relatively stable interfaces" [Frigant, (2005), p.30].

Without limiting it to this aspect, product decomposability is a strategy to reduce the production complexity and rationalisation. A modular object is then a complex product composed of subassemblies, produced independently of one another but that can be linked together to form a coherent system, stabilised by standard interfaces.

Through decomposability, the modularisation of complex products enables to reduce the complexity of technical objects. It also enables to rationalise the organisation of production processes and the hierarchical structure, as recalled by Simon through his parable about watchmakers named *Tempus* and *Hora*.

*Tempus* and *Hora* were two watchmakers renowned for the quality of the watches they would design. They had such a good reputation that they were often interrupted during their work by clients who wanted to place an order. The more famous they

were becoming, the more calls they would receive in their respective workshop. However, Hora's activity prospered while Tempus went bankrupt. The explanation of these two fates is the following: each watch designed by both matchmakers involved 1,000 components. Hora designed his watches in a way that "he would combine ten elementary components into small subassemblies, and then he would combine ten subassemblies into larger subassemblies, and these in turn could be combined to make a complete watch" [Simon, (1962), p.470]. By contrast, Tempus did not decompose into stable and homogenous subassemblies. Every time the phone would ring, he would abandon his current assembly which would immediately fall apart. After each interruption, Tempus would start again the entire design process. Considering a reasonable interruption probability for both men, Simon (1962, p.470) shows that in the end, it takes 4,000 times more time to Tempus than Hora to finish assembling a watch.

The perspective developed by Sanchez and Mahoney (1996) is rather different; it is indeed not focused on the product. They developed the idea according to which there are positive correlations between the evolution of complex products development processes and the organisational forms that create them. The modularity-product perspective is coupled with an organisational perspective in which "modularity is presented like a specific structure in terms of coordination and labour division that particularly aims at minimizing transaction costs" [Cohendet et al., (2005), p.122].

With the works of Langlois (2002), Baldwin and Clark (2000) and Brusoni and Prencipe (2001), both perspectives of technical and organisational modularity are completed by a strong cognitive dimension. This dimension means that the knowledge underlying the products (design, production, and assembly) falls within the modules' combination and assembly (Nielsen, 2003). In other words, modularisation is also a modularisation of bodies of knowledge that give rise to the products.

In fact, Brusoni and Prencipe (2001, p.184) questioned this product-organisation-knowledge trilogy when they recalled that the literature on modularity was based on three basic premises:

- 1 "there exists a positive correlation between product, organizational and knowledge modularity
- 2 modular product architectures enable increasing specialization, both within and across companies
- 3 modular product architectures allow for coordination to be achieved with minimum managerial effort".

From this point of view, modularity represents the end of integrated firms and the emergence of particular organisational forms; which come within the theories of inter-organisational links, such as the 'producers networks' (Langlois and Robertson, 1992), 'modular networks of production' (Sturgeon, 2002), 'loosely coupled networks' (Brusoni and Prencipe, 2001). Also, modularity becomes a management strategy for the supply chain and the inter-firms relationships.

## **5 Modularity and system integration: the emergence of pivot-firms**

Modularisation is not a new phenomenon in the aeronautics industry (Araujo et al., 1999; Amesse et al., 2001; Acha et al., 2007). Recent changes announce a deepening of this



type of organisation as well as a strong redistribution of the roles of the firms involved in the aircraft production process.

A modular structure involves a product architecture decomposable into modules connected to each other by more or less standardised interfaces (Baldwin and Clark, 2000). The architect firm designs the general architecture of the product and manages the interfaces between the different modules during the integration of these modules (Ulrich, 1995; Bresnahan and Greenstein, 1999; Frigant, 2005). The architect-integrator therefore occupies a strategic position all along the value chain, but mostly intervenes in the upstream and downstream stages.

Furthermore, a modular product architecture facilitates incremental innovation, either by adding functionalities to product components, or by transforming one of these components. A modular product can therefore regularly respond to modifications in demand (Langlois and Robertson, 1992). Similarly, it speeds up the development of variations on a same design. This is typically illustrated by the A320, 321, 319 and 318 families of aircraft.

In a context of pure modularity, an architect firm's approach is to divide the final product into a set of sub-units that are independent in their conception and their production as well as interdependent when it comes to connect them in order to create the final product. Modularisation is then based on the technical and cognitive division of the production processes (Ulrich, 1995; Baldwin and Clarck, 2000). From then on, the processes that generate the products are such that the organisation of the firms active in those processes must be rethought (Langlois, 2003; Frigant, 2005). In a modular organisation, the architect delegates the design and the production of modules and components of the end product to specialised firms (Ulrich, 1995; Sanchez and Mahoney, 1996; Brusoni and Prencipe, 2001; Ulrich and Eppinger, 2008). Its role as a supervisor is to control the manufacturing of sub-units and to ensure the compatibility of the interfaces between modules.

The increasingly modular organisation at Airbus mainly involves delegating to specialised firms – pivot-firms or 'hub firms' (Jarillo, 1988) – increasingly important components, for instance the whole aero structure, embedded systems, the landing gear... The bigger the size of the units and sub-units, the lesser the coordination duty of the architect, as the number of interfaces to control decreases along with the number of modules that need to be assembled. The economic advantage of modularisation is also clear in terms of the cost decrease through the reduction in the number of direct partners. The pivot-firm can then play the role of architect firm for the units that it is in charge of. It articulates the technical and organisational competencies of the other participants (Kechidi, 2008; Cagli et al., 2009; Gilly et al., 2011).

The relationship between the architect firm and the network of firms it structures depends of the nature of the interface (Araujo et al., 1999; Nellore, 2001; Acha et al., 2007; Cagli et al., 2012). Araujo et al. (1999) distinguish four kinds of interfaces:

- standardised interfaces are generated by the production of standard goods from ordinary technologies
- specified interfaces are explicitly codified in precise specifications
- 'translation' interfaces are more linked with the definition of the functionalities of the product than with the product itself or with the conditions of its use

- interactive interfaces are co-determined by the participants to the interaction; they put in play specific complementary assets.

The pivot-firm articulates the translation and interactive interfaces. It develops combinatorial skills. It has the capacity to mobilise a set of internal and external resources in order to participate in the design and production take-over of a major technical sub-unit of the final product.

In configuration taking place, a firm-pivot in charge of aerostructures or avionics systems, must meet the criteria of size, financial and technological capabilities to share industrial and financial risks. The optimal configuration of subcontractors network consist in a large companies in the first level in charge of all technical and industrial homogeneous module (aero structures, electrical wiring, embedded systems...) related with a wide network of suppliers and subcontractors. The main characteristic of the firm-pivot is to able to share the risks according to the formula, 'the equipment is paid when the aircraft is sold'. Firms-pivots are a new kind of tier one.

In this topic, a pivot-firm is a firm that:

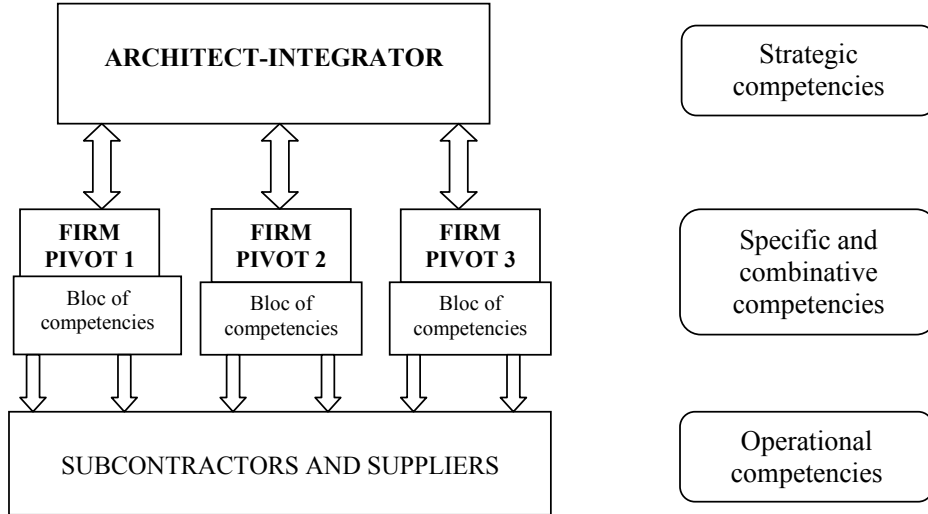
- Has specific competencies. These specific skills involve a homogeneous set of knowledge and know-how (avionics, aero structures, engine nacelles...), linked with the design and/or the production of major modules or of important components for the final product.
- Has combinative competencies. These skills are technical and organisational. They are said to be combinatorial because they put their holders in the position to manage the interfaces with the other participants in the design and production process, in other words the architect-integrator and the subcontractors at the lower levels.
- Participates in the co-specification of the products. In particular in an industry of complex goods, this capacity is a direct consequence of the former two. From an organisational standpoint, co-development and co-specification generates structures that encourage decreases in time frames and costs. The economic advantage of modularisation – combined with outsourcing – is, again, clear in terms of reducing the transaction and contract management costs through the decrease in the number of direct partners.
- Plays the role of an architect-firm for the units that it is in charge of. The relationship between the architect-firm and the network of firms that it structures depends on the nature of the modular interfaces.

On that basis, the 'optimal' configuration for a subcontracting network would include big pivot-firms for homogeneous technical-industrial sets (aerostructures, wiring harness, embedded systems...), other smaller pivot-firms and finally suppliers and sub-contractors. The characteristic of the pivot-firms would be to share the risks according to the principle that 'the equipment is paid for only if the aircraft is sold'.

Cagli et al. (2009) illustrate the interactions between the pivot-firms and Airbus and Boeing with examples. For instance, the Safran group, through its different subsidiaries, positions itself on a high number of strategic technical modules and components in the production of an aircraft. Through Techspace Aero, Messier-Dowti and Messier-Buggati, Safran participates in the design and production of aircrafts' engines, wheels, brakes and

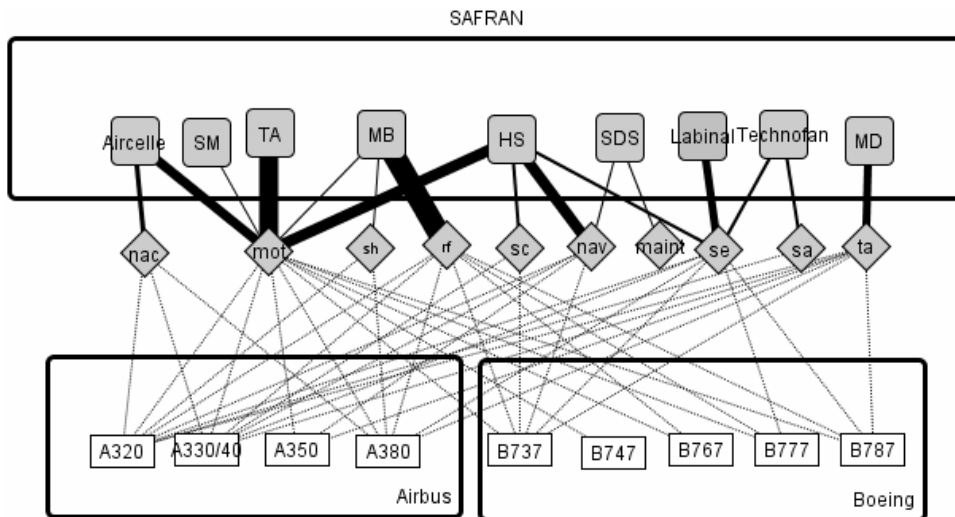
landing gears. Earlier in the paper, we have seen that the components come within the strategic segmentation of Airbus' supply chain<sup>4</sup>.

**Figure 1** A strategic segmentation of supply chain



As a pivot actor, Safran has mainly business relationships with Airbus, even if it participates to the subcontracting chain of Boeing (48 business relationships with Airbus and 24 with Boeing). Besides, if some subsidiaries of the group (Labinal, Messier Buggati and Messier-Dowty) are Boeing global partners, only Airbus considers the entire group as one of its major subcontractor. This relation with Airbus can be explained by the geographic proximity with the group's subsidiaries and by how long they have had relationships (Kechidi and Talbot, 2010; Gilly et al., 2011).

**Figure 2** Business relationships between Safran, Boeing and Airbus



## **6 Conclusions**

Aircraft has become an increasingly complex technical object. This complexity has generated changes in the organisation of aircraft manufacturing. The case of Airbus is significant in this evolution. In comparison with Boeing, it is clearly Airbus that has been able to draw the most advantages from the modularisation trend of the past few years. According to us, the dynamic of technical and organisation innovation, as well as the industrial model that generated it, have played a large part in the success of Airbus on the civil aviation world markets.

The industrial organisation which has progressively been put in place is characterised by:

- A refocusing of activities on the core of Airbus's business. With Power 8, Airbus has accelerated this refocusing. It has evolved from a status of 'aircraft manufacturer' to the status of 'architect-integrator'. The position of architect-integrator, in the upstream stage (design of the aircraft) and the downstream stage (assembly of the components and liaising with airlines) of the production and commercialisation process is strategic because it enables them to control the entirety of the value chain. This control means that the technologically strategic or profitable components continue to be manufactured internally.
- The development of modularisation in aircraft manufacturing. A real technical evolution, it has been accompanied by important organisational mutations in Airbus as well in its partners.
- The outsourcing of activities deemed to be non-strategic. Outsourcing is not a new phenomenon in the politics of industrial acquisitions. The novelty is that it concerns new activities and/or involves larger volumes. As a consequence of the development of modularisation, the outsourced 'technological packages' now represent systems and entire technical sets.
- The reinforcement of the role of Airbus's major partners. These firms, that produce important 'technological packages', in turn play the role of architect-integrators for the sets they produce. They have the specific capacity to articulate the vertical relationships between the architect-integrator and the other (inferior) levels of sub-contracting or of supplying components and equipment. More than simple 'tier one' or risk sharing partnerships, these firms become essential partners in the design and manufacturing of the aircraft.

The strong outsourcing as well the international fragmentation of the production process are however important limitations on this organisational model. The difficulties encountered by Airbus for the assembly of the A380 and by Boeing for the B787 reflect the limitations of outsourcing and modularisation. The recomposition of the industrial puzzle poses real problems with regard to the management of the different technical and organisational interfaces. These problems directly affect the profitability of the projects. Indeed, according to the Seattle Times of 18 December 2010, the cost of the 787 has increased from 5 billion dollars to between 12 and 18 billion dollars.

Boeing acquiring Vought Aircraft's share of Global Aeronautica can be interpreted as a return to the internalisation of a part of the construction of the aero-structure. Similarly, Airbus keeping the manufacturing of the central box and the wings of the A350 internal

is clearly a sign of the breaks being put on outsourcing. The elements which in the past pushed forward the performance of this production model seem today to be holding it back.

## References

- Acha, V., Brusoni, S. and Prencipe, A. (2007) 'Exploring the miracle: strategy and management of the knowledge base in the aeronautics industry', *International Journal of Innovation Technology Management*, Vol. 4, No. 1, pp.15–39.
- Agrawal, A. and Cockburn, I.M. (2003) 'The anchor tenant hypothesis: exploring the role of large, local, R-D intensive firms in regional innovation system', *International Journal of Industrial Organization*, Vol. 21, No. 9, 1227p.
- Amesse, F. et al. (2001) 'Issues on partnering: evidences from subcontracting in aeronautics', *Technovation*, Vol. 21, No. 9, pp.559–569.
- Araujo, L., Dubois, A. and Gadde, L.E. (1999) 'Managing interfaces with suppliers', *Industrial Marketing Management*, Vol. 28, No. 5, pp.497–506.
- Baldwin, C.Y. and Clark, K.B. (2000) *Design Rules: The Power of Modularity*, The MIT Press, Cambridge, Mass.
- Bresnahan, T. and Greenstein, S. (1999) 'Technological competition and the structure of the computing industry', *Journal of Industrial Economics*, Winter.
- Brusoni, S. and Prencipe, A. (2001) 'Unpacking the black box of modularity: technologies, products and organizations', *Industrial and Corporate Change*, Vol. 10, No. 1, pp.179–205.
- Cagli, A., Kechidi, M. and Levy, R. (2009) 'Gestion stratégique de la supply chain et firme-pivot dans le secteur aéronautique', *Revue Française de Gestion Industrielle*, Vol. 28, No. 2, pp.89–106.
- Cagli, A., Kechidi, M. and Levy, R. (2012) 'Complex product and supplier interfaces in aeronautics', *Journal of Manufacturing Technology Management*, Vol. 23, No. 6, pp.717–732.
- Cagliano, R., Caniato, F. and Spina, G. (2004) 'Lean, agile and traditional supply: how do they impact manufacturing performance?', *Journal of Purchasing and Supply Management*, Vol. 10, Nos. 4/5, pp.151–164.
- Cohendet, P., Diani, M. and Lerch, C. (2005) 'Stratégie modulaire dans la conception. Une interprétation en termes de communauté', *Revue Française de Gestion*, Vol. 5, No. 158, pp.121–143.
- Cooke, P. and Ehret, O. (2009) 'Proximity and procurement: a study of agglomeration in the welsh aerospace industry', *European Planning Studies*, Vol. 17, No. 4, pp.549–567.
- Destefani, J. (2004) 'A look at the Boeing's outsourcing strategy', *Manufacturing Engineering*, Vol. 132, No. 3, pp.65–73.
- Ehret, O. and Cooke, P. (2010) 'Conceptualising aerospace outsourcing: Airbus UK and the lean supply approach', *Int. J. Technology Management*, Vol. 50, Nos. 3/4, pp.300–317.
- Frigant, V. (2005) 'Vanishing Hand versus Systems Integrators. Une revue de la littérature sur l'impact organisationnel de la modularité', *Revue d'économie industrielle*, No. 109, 1er Tri., pp.29–52.
- Frigant, V., Kechidi, M. and Talbot, D. (2006) *Les territoires de l'aéronautique EADS, entre mondialisation et ancrage territorial*, L'Harmattan, Paris.
- Gilly, J-P., Talbot, D. and Zuliani, J-M. (2011) 'Firms hub and the dynamics of regional innovation: case studies of Thales and Liebherr in Toulouse', *European Planning Studies*, December, Vol. 19, No. 12, pp.2009–2024.
- Jarillo, J.C. (1988) 'On strategic networks', *Strategic Management Journal*, Vol. 9, No. 1, pp.31–41.

- Kechidi, M. (1996) 'Coordination inter-entreprises et relations de sous-traitance: le cas d'Aérospatiale', *Revue d'Economie Régionale et Urbaine*, No. 1, pp.99–120.
- Kechidi, M. (2006) 'Les relations verticales dans l'industrie aéronautique: le cas de la sous-traitance d'Airbus France', *Revue Française de Gestion Industrielle*, Vol. 25, No. 2, pp.21–40.
- Kechidi, M. (2008) 'Modularité, firme-pivotn innovations: un nouveau modèle d'organisation industrielle pour Airbus', *Revue Française de Gestion Industrielle*, Vol. 27, No. 2, pp.29–45.
- Kechidi, M. and Talbot, D. (2010) 'Institutions and coordination: what is the contribution of a proximity-based analysis? The case of Airbus and its relations with the subcontracting network', *International Journal of Technology Management*, Vol. 50, Nos. 3/4, pp.285–299.
- Langlois, R.N. (2002) 'Modularity in technology and organization', *Journal of Economic Behavior & Organization*, Vol. 49, No. 1, pp.19–37.
- Langlois, R.N. (2003) 'The vanishing hand: the changing dynamics of industrial capitalism', *Industrial and Corporate Change*, Vol. 12, No. 2, pp.351–385.
- Langlois, R.N. and Robertson, P. (1992) 'Networks and innovation in a modular system: lessons from the microcomputer and stereo component industries', *Research Policy*, Vol. 21, No. 4, pp.297–313.
- Lawrence, P. and Thornton, D. (2005) *Deep Stall, The Turbulent Story of Boeing Commercial Airplanes*, Asgate, Aldershot.
- Muller, P. (1989) *Airbus, l'ambition européenne. Logique d'Etat, logique de marché*, L'Harmattan, Paris.
- Nellore, R. (2001) 'The impact of supplier visions on product development', *Journal of Supply Chain Management*, Vol. 37, No. 1, pp.27–36.
- Nielsen, J. (2003) 'Modularité et innovation', Working Paper IMRI, n°03/2003.
- Niosi, J. and Zhegu, M. (2010) 'Anchor tenants and regional innovation systems: the aircraft industry', *International Journal of Technology Management*, Vol. 50, Nos. 3/4, pp.263–284.
- Nolan, P. and Zhang, L. (2002) 'The challenge of globalization for large Chinese firms', *World Development*, Vol. 30, No. 12, pp.2089–2107.
- Rose-Anderssen, C., Baldwin, J., Ridgway, K., Allen, P. and Varga, L. (2008) 'Aerospace supply chains as evolutionary networks of activities: innovation via risk-sharing partnerships', *Creativity and Innovation Management*, Vol. 17, No. 4, pp.304–318.
- Rose-Anderssen, C., Baldwin, J., Ridgway, K., Allen, P., Varga, L. and Strathern, M. (2009) 'A cladistic classification of commercial aerospace supply chain evolution', *Journal of Manufacturing Technology Management*, Vol. 20, No. 2, pp.235–257.
- Sanchez, R. and Mahoney, J.T. (1996) 'Modularity, flexibility, and knowledge management in product and organization design', *Strategic Management Journal*, Special issue: Knowledge and the firm, Winter, Vol. 17, pp.63–76.
- Simon, H. (1962) 'The architecture of complexity', *Proceedings of the American Philosophical*, Vol. 106, No. 6, pp.467–482.
- Sturgeon, T.J. (2002) 'Modular production networks: a new American model of industrial organization', *Industrial and Corporate Change*, Vol. 11, No. 3, pp.451–496.
- Talbot, D. (2000) 'Institutional dynamics and localized inter-firm relations: the case of Aérospatiale and its subcontractors in Toulouse', *European Urban and Regional Studies*, Vol. 7, No. 3, pp.223–236.
- Ulrich, K. (1995) 'The role of product architecture in the manufacturing firm', *Research Policy*, Vol. 24, No. 3, pp.419–440.
- Ulrich, K. and Eppinger, S.D. (2008) *Product Design and Development*, 4th ed., McGraw-Hill, New York.

## Notes

- 1 Emmanuel Grave, Vice-President of the Aeronautics Division of Thales, Air & Cosmos, November 24th 2006.
- 2 The mutations that need to be done are that more crucial than those choices are kind of imposed by Boeing that has put very high the degree of innovations as much for the 777 as for the 787. It is under that pressure and that of airline companies that Airbus had to review its position and inject more than €10 million in order to develop a version of the A350 capable of competing with Boeing.
- 3 For example, Boeing subcontracts more than 70% of the equipment of B787. Airbus considers a similar approach for A350 by subcontracting 50% of the tasks linked with the aero structure to external firms.
- 4 *Source:* Airframer database.

*Caption:* The rounded squares represent the firms and their subsidiaries. The rhombuses show the technical component on which those subsidiaries are working on. The thickness of the lines is proportional to number of business relationships that link the subsidiaries with the technical components. The rectangles at the bottom represent the aeronautics programmes that are linked with those business relationships.

*Abbreviations of the technical components:* navigation and flight management systems (nav); communication, maintenance and alert systems (maint); hydraulic systems (sh); carburetion systems (sc); electric systems (se); flight control and vectoring systems (cont); landing gear (ta); engines (mot).

*Abbreviations of the subsidiaries:* MB: Messier-Bugatti; MD: Messier-Dowty; HS: Hispano-Suiza; SM: Snecma Moteur; SDS: Sagem Défense Sécurité; TA: Techspace Aero.