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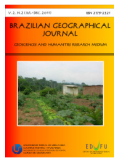

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Toulouse and the On-board Systems Cluster: a Late Result from One Century of Local and National Policies

Doctor Michel Grossetti
Professor Graduate Studies at Département de Géographie, Université de Toulouse. Allées A. Machado, 31058 Toulouse Cedex 1, France, Toulouse, France. **E-mail:** rgros@univ-tlse2.fr

Doctor Jean-Marc Zuliani
Professor Graduate Studies at Département de Géographie, Université de Toulouse. Allées A. Machado, 31058 Toulouse Cedex 1, France, Toulouse, France. **E-mail:** zuliani@univ-tlse2.fr

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ABSTRACT

The cluster of on-board system is a key part of Toulouse industrial activity. This cluster links several kinds of firms from different sectors and academic laboratories, in the field of engineering, aerospace, electronics systems and software. In this presentation, we will argue that this technological cluster is partly an unexpected result of loosely connected local and national policies and industrial initiatives between 1900 and 1980. The recent "pôle de compétitivité Aerospace Valley" policy was more a result of this cluster than a cause. But from an analysis of the projects financed through the policy, we can make the hypothesis that this policy will reinforce the integration of the cluster without modifying significantly its structure.

MOTS-CLES:
Toulouse
Système industriel
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RESUME – TOULOUSE ET LE CLUSTER DES SYSTEMES EMBARQUES : L'ABOUTISSEMENT D'UN SIECLE DE POLITIQUES LOCALES ET NATIONALES Le cluster des systèmes embarqués est un élement clé du système industriel de la region métropolitaine de Toulouse. Ce cluster associe plusieurs types d'entreprises de différents secteurs et des laboratoires universitaires, dans les domaines de l'ingénierie, de l'aéronautique et du secteur spatial, de l'électronique et de l'informatique. Dans cet article, nous soulignerons que ce cluster est en partie le résultat inattendu de politiques locales et nationales peu connectées entre elles, ainsi que d'initiatives industrielles, survenues entre 1900 et 1980. Le recent "Pôle de compétitivité Aerospace Valley" est plus l'aboutissement de ce cluster que sa cause. Par l'analyse des projets récents financés par le "Pôle de compétitivité", nous pouvons faire l'hypothèse que cette politique renforcera l'intégration du cluster toulousain des systèmes embarqués sans modifier significativement la structure.

PALAVRAS-CHAVES:
Toulouse
Sistema Industrial
Aeroespacial

RESUMO – TOULOUSE E ON-BOARD CLUSTER SYSTEM: UM RESULTADO DE UM SÉCULO DE POLÍTICAS LOCAIS E NACIONAIS. O On-board Cluster System é uma parte fundamental da atividade industrial de Toulouse. Este cluster interliga varias empresas de diferentes setores acadêmicos no campo da engenharia, aeroespacial, sistemas eletrônicos e software. Neste artigo argumentamos que este cluster tecnológico é, em parte, um resultado inesperado da frágil relação política locais e nacionais e de suas iniciativas industriais dentre 1900 e 1980. A recente política para "pôle de compétitivité Aerospace Valley" foi mais um resultado deste contexto. Mas a partir de uma analise dos projetos financiados oriundos da política a este relacionada, podemos elaborar uma hipótese que esta política irá reforçar a integração do cluster sem modificar significativamente a sua estrutura.

1 Introduction

In recent years, the idea of policies evaluation dedicated to support clusters development and formation emerged (Schmiedeberg, 2010, Raines, 2003).

Theses evaluations are difficult to do for several reasons. Firstly, assessing public policies effects is a very difficult task. It's completely impossible to focus on policies themselves, because, doing this, the best that one can obtain is a description of their making, their aims, and their tangible functioning. To have and idea of their efficiency, it's necessary to study the social reality that these policies are supposed to change. In doing that, one have to avoid two traps. The first trap is considering policies as negligible compared to the strong tendencies in the evolution of societies, as it's usually done in most part of the literature on social changes. The second trap is considering that all changes (and the whole social reality) can be explained by policies, as does most of the research in political science.

As a result, finding the real place and impact of policies is not an easy task. Studying social reality beyond policies is necessary, but it's not sufficient: how can we establish changes? How can we put changes down to a specific policy and not to other factors? If a policy misses its short-term objectives, is it necessary a failure? Evaluating past policies is difficult, but evaluating current policies is almost impossible. In the case of policies designed to enhance local economic development, there is a second problem: policy makers systematically label their policies after the terms used by researchers to describe social reality: for example, "technopoles" can mean local systems of innovation or a local policies designed to establish systems of this kind, and it's the same problem with "local productive systems", and more recently for "clusters". That's the reason why we need to make a clear difference between "clusters" as socio-economic forms (Porter, 1990, 1998) and "clusters" as public policies designed to make or to enhance "clusters" in the first meaning. Third, one has to introduce the question of time: the effects of a policy are rarely contemporaneous with the policy itself. Cluster policies take place in a long series of policies to promote local economic development. It is difficult to discern the effect of a given policy, especially if it is recent, in all actions that were undertaken over time. Current socio-economic "clusters" are not necessarily the result of current "cluster" policies. Fourth and finally, when the policies are related to existing clusters, it may happen that the causality is reversed. In this context, the cluster configuration determines the policy.

We illustrate these remarks by examining the case of a French policy (the "pôles de compétitivité") by looking at its implementation in through the case of the aerospace industry in Toulouse. In 2004, the French government launched a policy to develop the « convergence of industrial, scientific and training of the same territory, on the model of clusters », the latter being regarded as a source of innovation, source of attraction and a hindrance to offshoring[1]. He has formulated a « specification »[2] which defines a « cluster » as « the combination on a given geographical area, of training centers and research units, public or private, engaged in a partnership approach designed to identify synergies around common innovative projects » (p.4). In 2005, 71 centers have been certified and have secured funding (1.5 billion euros for the period 2009-2011). Among those who received the most funding are 7 pin «world »[3]. One of these clusters is « Aerospace Valley » whose specialties are aerospace, space and information and communication technology. It covers the Regions of Midi-Pyrenees (whose main city is Toulouse) and Aquitaine (Bordeaux). It brings together 225 companies, 69 research institutes or other training organizations and 122 other organizations, which represents about 65,000 jobs.

The cluster «Aerospace Valley» can be considered as a new device for development policies supporting the sectors of aeronautics, space industry, as well as the more cross-domain of on-board systems. The current challenge is to open the application areas of embedded systems beyond applications for transport (aviation, space industry, automotive and rail), to health and medical equipment. This medical perspective requires institutional cooperation with medical foundations as another cluster is also installed since 2005 in Toulouse, the pole « Cancer-Bio-Health ». In 2009, the embedded systems activities represented approximately 40% of innovative projects (about nearly a hundred in all) for which the cluster provides a label, which is then used to obtain funding from national government or from the regional government (Zuliani, 2008). The cluster « Aerospace Valley » is a development agency, which carries a mixed public-private partnership, but where the weight of large companies (EADS, Thales, Dassault, Continental ...) seems increasingly important alongside various local authorities. Its policy of supporting technological development is done in two ways. It's both a sectoral approach, in conjunction with the major lines of business of the companies represented at the Pole of Competitiveness, and a transversal approach which supports the development of embedded systems with the aim of promoting and diffusing these technologies and applications into the sectors of transportation (aerospace, automotive, rail, satellite industry ...) and beyond (medical equipment, home automation, energy ...).

We will argue that recent or current policies have no big effect on Toulouse's current «on-board systems» cluster, which is rather the result of former policies endeavoured at the beginning of the 20th century or in the 1960 years. Then, we try to link the formation of this local socio-economic « cluster » in Toulouse to current policies … and policies from the last century.

We will begin by briefly summarize the long history of the socio-economic cluster, tracing back the making of this system from the beginning of the 20th century and the first local policy dedicated to promote local economic development. We will then

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1 http://competitivite.gouv.fr/quest-ce-quun-pole-de-competitivite/les-enjeux-de-la-politique-des-poles-477.html

2 http://competitivite.gouv.fr/documents/commun/Politique_des_poles/1ere_phase_2005-2008/Premiere_labellisations_des_poles/cahier_des_charges_poles.pdf

3 There are also 11 poles «with global ambitions», the others being regarded as «national».

describe what we call the « local system of competence » (Grossetti, Zuliani, Guillaume, 2006) of on-board systems and more generally on systems for transport industries, which correspond partly to the social reality of the so-called object «Aeronautics, Space and On-board Systems - pôle de compétitivité». We will argue that this cluster cannot be defined by a kind of product, but by a kind of competence and a local job market. We will also argue that the « pole de compétitivité » as a cluster policy has a few effects on the socio-economic cluster, which is the result of a very long history.

2 The long and difficult economic awakening of a town without big industry

Three periods can be identified in the development path of Toulouse. Until the middle of the 20th century, excepting the chemical industry, the economy is characterised by small-scale and scattered industries producing mainly manufactured goods. A big change occurred in the years after 1945, when the French government decided to strengthen aeronautical activities and decentralised several specialised education and research institutions in Toulouse. The enhanced local scientific potential was progressively associated with the growth of aeronautics and space industry in the 1970s. The following shifting of the aircraft industry from electromechanical to digital technology gave birth to the current local innovation system.

Located at an easy crossing of the Garonne, Toulouse has been a focal point for trade between the Pyrénées, the Mediterranean and the Atlantic. Once a major metropolis of Western Europe, Toulouse was in the 19th century a middle-sized commercial and administrative centre. Chemistry was the only large industry in Toulouse until the 1950s. The gunpowder factory employed until 30,000 persons between 1914 and 1918, then from 1924 on, a patent confiscated from defeated Germany was used to produce fertilisers. The industrial landscape was mainly characterised by small and dispersed businesses, employing less than 100 workers and producing large quantities of finished manufactured goods (hats, edge-tools, cutlery, bricks, tiles, faience) for external markets (Olivier 2007). Even the production of aircraft, which developed during the First World War, was a small-scale activity that did not integrate a high level of technology. Two individual entrepreneurs of the region, Latécoère and Dewoitine, created their own business in the manufacture of airplanes and equipments for airplanes.

Parallel to this, local politicians and academics planned to implement an activity based on hydroelectricity, which was justified by the proximity of the Pyrénées. The idea came from academics, Paul Sabatier ((Nobel Prize 1912, Chemistry, dean of the science faculty since 1905) and Charles Camichel (professor of physics) who convinced the mayor Albert Bedouce to support the creation of a new institute of electrical engineering designed to train workers of the future hydroelectric industry. In 1906, the municipality decided to fund the new institute for 20 years from its creation in 1907, giving the faculty an annual grant equivalent to the wages of Camichel and an assistant, and also to a part for the daily paperwork the of the institute. The municipality gave also a building. The faculty of science created also without the funding of the municipality an institute of chemistry (1906) and another on agronomics (1909). It was a major turn in the history of the local university, as at this period started one of the most advanced engineering teaching institution in France. The electrical engineering institute was a great success. In 1913 half of the students of the faculty of science were studying in that institute. The electrical institute gave also to the Local Faculty of Science an important advantage in engineering as Grenoble, Nancy, Toulouse and Lille where the only places in France for studying this matter. Together with the other institutes, it gave to the University of Toulouse a strong orientation towards engineering.

However, despite a political will and the presence of local competences in this field, no electrical industry comparable to Grenoble's one has ever been developed in Toulouse. The lack of an existing industry that could have supported the production of this energy, as well as the remoteness of the city from the mountains, explain why the dream of hydroelectricity was finally given up. Though this activity enabled the settlement of some metallurgic factories, it did not trigger off the creation of local companies. The aeronautical activity also remained cut off from the faculty of science and its institutes until the 1970s. Unlike in Grenoble, businesses that were created in Toulouse did not profit from the local research potential and the graduates had to leave the city to find work elsewhere.

An important change took place in Toulouse in the period following World War 2 with the emergence of a strong scientific pole in engineering and the growth of aeronautics and space industry. The presence of the technical institutes gave Toulouse's university an opportunity to be pioneer in new fields of engineering: chemical engineering (creation of the first French institute of chemical engineering in 1946); automatics (engineers school, laboratory), and computing (first French engineers school together with Grenoble). The advantage took by the beginning of the century grew to give Toulouse's university a leadership in engineering, together with Grenoble and Paris (Grossetti, 1995).

But the huge scientific pole had no connection with the local industry which was still weak. At the end of the 1950s, the French State decided to strengthen aeronautical activities through the decentralisation of several education institutions specialised in engineering and research. Local scientific leaders influenced the officials in charge of the Regional action plan. As a result, in 1958, they succeed to transfer the National school of aeronautics to their city. Other changes in the local higher education system occurred in the 1960s, with the transfer of the National Higher School for Aeronautical Engineering (ENSICA) in 1961 and the National School of Civil Aviation in 1968. A local branch of the National Office for Aeronautical Studies and Research (ONERA) was also created, along with a National Institute for Applied Sciences (INSA).

The decision in 1963 to decentralise part of the National Centre for Spatial Studies (CNES), created in 1961, had a great impact on the local economy in Toulouse. It has enabled to connect industry with the local research and higher education system for the first time since the beginning of the century. The CNES was indeed not only a research centre but also an industrial agency in charge of developing the national spatial industry. It used to work with firms that settled later in Toulouse (Matra in 1979, Alcatel in 1982) and grew up by hiring a large number of local graduates and quickly connected with local laboratories.

The actors of the training and research system in electrical engineering, electronics and computer have played a major role in the decision to decentralise space industry in Toulouse. They also influenced the decision to settle a Motorola factory, which triggered the development of R&D activities in wireless, broadband, automotive communications technologies and embedded electronic products. Then the researchers' lobbying has been decisive for the shifting of the aircraft industry from electromechanical technology to digital technology, with the Airbus A320 programme.

All these major changes gave birth to a new local innovation system in Toulouse. The technological and economic take-off has taken place between 1975 and 1985, as the key elements of the current system went together (Grossetti, 1995). The establishment of the "satellite" divisions of the CNES resulted in the relocation of service companies in Toulouse. Highly specialised firms in satellite decks (Alcatel, Matra Marconi Space), satellites programmes (SPOT, Argos) or satellite imagery and localisation system (SPOT Images, CLS Argos) as well as Météo France, with its high-tech meteorological computer centre, settled in the area of Toulouse from the 1980s onwards. Matra and Alcatel launched an extensive recruitment program locally as well. Electronic companies (Motorola, Thomson), who had settled in the 1960s mainly for large scale mass manufacturing turned into development centres and recruited engineers. In the same period, Aérospatiale recruited computer engineers from the local educational system and developed an activity of numerical modelling and command systems. Their department becoming more important, they obtained from the general management of Airbus to shift aircrafts commands to electrical and numerical systems for the Airbus A320. This technological shift gave Airbus a big advantage in the competition with Boeing, with the huge success of the A320. Later, the weight of the software loaded into Airbus airplanes Airbus will not cease growing on the whole by civil apparatuses of the range Airbus to attain about 80 megabytes on the Airbus A380 today.

Another area of research and development is structured in Toulouse in the late 70s in the field of automotive electronics with the commitment demonstrated by Renault to create its own capacity to develop innovative electronics, from design to manufacture of computers. A branch is created with the American Bendix to form the entity Renix. Also in 1979, Toulouse is chosen from several French cities for the implementation of Renix to extent research s on systems as this field had previously been undertaken between the CNRS laboratory specializing in automatic (LAAS) and Renault. Various key products of the future electronic architecture of all Renault vehicles were developed: ignition, fuel injection, cruise control and the computer of the automatic gearbox. And even if Renault sold Renix to Bendix in 1985, the center of R & D Toulouse cooperated with many car manufacturers to develop new applications in electronic fuel injection and ABS brakes in particular. In the 90s, the entry in the Siemens group marked a new stage with an extension of R & D in the field of sensors and computers embedded in the whole group and then the engine compartment. Beforehand, a spin-off of Bendix had led to the creation of the firm that is now Actia with 2,500 jobs. The collaborative strategy of Renix and Siemens with academic research led to the creation with LAAS CNRS of the joint laboratory Mirga (Mixed Research Group on Automotive Systems), which contributed to the genesis of IERSET, one of the major contributors in the field "on-board" in the cluster "Aerospace Valley."

The 90s and 2000s were marked by an intensification of forms of collaborative research with a commitment to horizontal relations between research centers and industries of transportation (aerospace, automotive, rail). The structure and orientation of the cluster changed by the emphasis on engineering expertise on on-board systems, that is to say, the definition of methods, techniques and tools for designing this kind of systems.

So, two kind of policies gave way to the electronics and computing cluster: 1) the Municipality policy of creating technical institutes in the Faculty of Science, that gave rise to a very important scientific pole in engineering; 2) the state policy of creating a branch of the French space agency, and encouraging the creation of branches of the main space companies. As a result, the shifting of the cluster to a more integrated LCS was more a spontaneous reaction of the local companies to the crises of 1991, 2001 and 2008. For example, during the closing of Freescale Semiconductors plant in 2009, more than 250 or 300 workers could be reclassified in others local enterprises of electronic and systems. The services companies restructured their organization, shifting from an organization by customer sectors to an organization by kind of competence, which made easier for engineer to shift from a mission in a sector to another mission in another sector. All of this was made possible by the technological convergence on system making favoured by research laboratories working with firms from different sectors.

3 Toulouse's cluster of "on-board" systems[4]

By «systems » we mean interfaced sets of electronic components and software. These are integrated into a device, a machine or another system which they run, control or regulate. These systems have grown rapidly over the years through different forms and now can be frequently found in aircraft as in automobiles, rockets and satellites and even in mobile telephones. When they are part of a mobile artefact, they are called « on-board » systems. As far as aeronautics are concerned, on-board systems carry out pre-defined tasks under strong constraints related to security and safety of operation, notably for flight controls. Their operation is termed « critical » inasmuch as they must never fail. But the « on-board » systems are not the only ones made in Toulouse. In space industry « on-board » systems are complemented by ground systems of guidance. And, beyond transport industries, many other kinds of systems can be made on the same basis of competence. So, when we will use « on-board systems » for the local cluster that we describe, it should be interpreted as a label for a wider set of activities.

In Toulouse, this cluster involves three kinds of local components: 1) local plants of big firms like Airbus, Thales, EADS, Continental, etc.; 2) local and national services companies (mainly computer services but more generally engineering); 3) public research laboratories and higher education establishments in engineering. Using almost a hundred of interviews made between 2001 and 2006 with persons working in executive position in the firms or laboratories, we drew the following diagram to present the relations between the involved organizations:

The production system of on-board systems in Toulouse and in the rest of the Midi-Pyrenees brings together a broad set of technical skills related to the production (design and manufacturing) of three separate sets: material, whether electronic, electrical or mechanical (eg sensors, actuators, systems for energy storage, power electronics, networks ...), software with a high degree of criticality, which is related to specific applications or more generic systems. These systems themselves require a range of diverse skills ranging from engineering to human-system interaction through architecture and integration, engineering, modeling, testing, certification, maintenance or dependability. These skills are represented among various types of companies forming in Midi-Pyrenees, and therefore Toulouse, a fairly complete value chain. First, there are great industrial principals such as Airbus in the aircraft industry, even if today, its mission is increasingly becoming the one of an architect and of an integrator of parts and components of aircraft, but with the strategic desire to keep the design and implementation of mainframe and sensitive parts and structures, especially in avionics. Other regional industries contribute in their respective fields, with the total production and delivery of a finished product, whether a satellite (Thales Alenia, Astrium), a propulsion system for motor TGV (Alstom), or electronic systems with computers for engines or interiors of automobiles (Continental). In these principals join « system integrators » also known as major subcontractors, primarily related to the aerospace, space segment and to a lesser extent, automotive electronics. Their role is completing systems, integrating several sub-assemblies, with a tendency more and more pronounced in developing links with the prime contractors for design activities. Finally, the regional productive system of industry stakeholders related to the activities of embedded systems is supplemented by a few suppliers that provide directly to contractors or

[4] This section is partly based on the paper by Jean-Marc Zuliani, "The Toulouse Cluster of On-board Systems: A Process of Collective Innovation and Learning", *European Planning Studies*, Volume 16, Issue 5 June 2008 , pages 711 – 726. See also Grossetti, Zuliani and Guillaume, 2006.

subcontractors major modules or equipments to be assembled or to provide an embedded system as a whole.

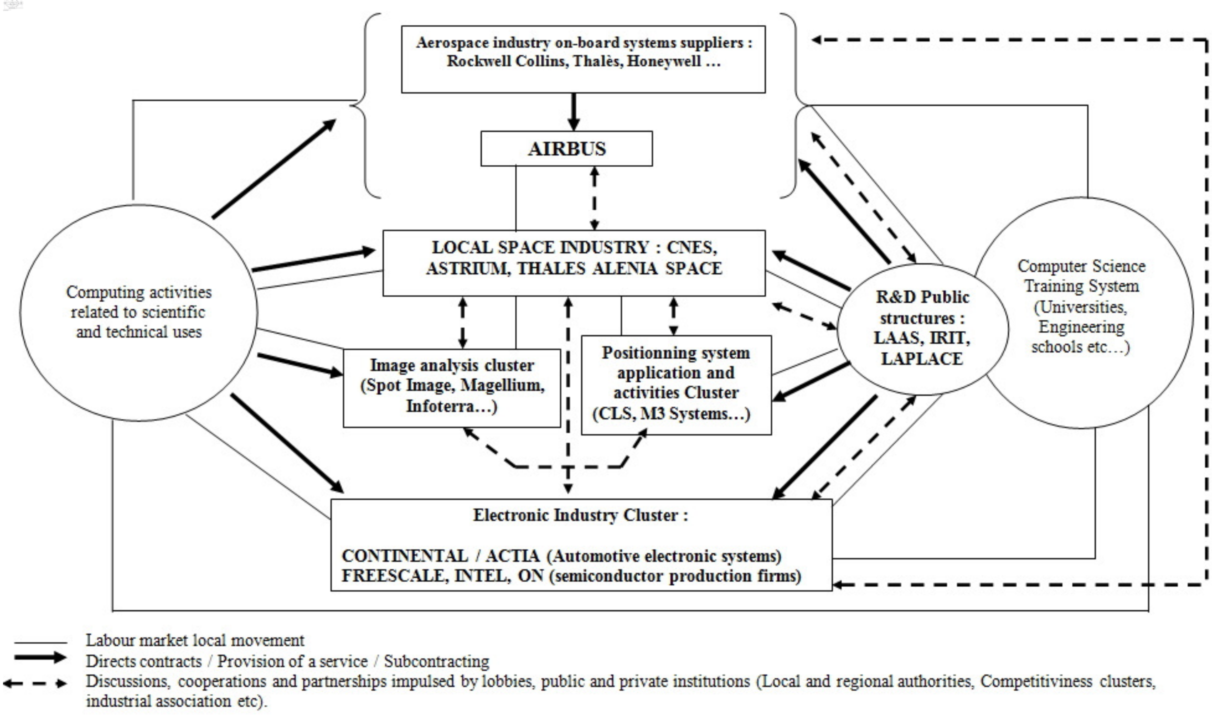
Regarding to the policies and systems of applied research, both large clients and major subcontractors are deploying strategies to work together. On one hand, they are involved in systems research or in communities or industry associations to develop technologies or to diffuse characters for embedded systems (open source, power electronics, systems engineering ...), or quality standards. On the other hand, their aim is to participate in sectoral research programs by strengthening bilateral links with research centers in the dependability and energy conversion for example. Thales and EADS initiated in recent years strategies to develop exchanges between teams of R & D belonging to different areas such as aeronautics and space industry. Their goal is then to improve methods and tools for software engineering that fits into the development of embedded systems in aeronautics and space industry.

The other major constituent components of the on-board systems cluster in Toulouse and in Midi-Pyrenees are providers of high level services, both for architecture and overall design, of an embedded system or for the supply of smaller software component or study. This layer of technology services providers in the industry runs a central interface in the organization of the on-board systems cluster with the capacity to combine and to cross-purposes a range of services: the geographic proximity of principals explains their ability to raise various useful skills for software activities and services required for the realization of the systems. First, the policy of restructuring subcontracting commitment by Airbus, the space industry (Thales Alenia, Astrium) and the French space agency (CNES) has had the consequence to gradually outsource development projects to engineering companies, which are mostly local plants of french large groups (Atos, Altran, Sogeti High Tech, Assystems...). They are involved in the upstream phase of product design as well as in developments of proper functions of on-board systems based on the specific needs of industrial clients. Their role is then extended to the coordination of the needs of a large sub-contractors network (so-called « capacity ») which produces and supplies most common technological studies. Beyond this regional cluster of technology based companies in the field of on-board systems, several local SMEs or start-up are also involved. This integration is mostly the result of their « cognitive ability » and of their capacity to deliver specific services, either because they develop innovative technological processes suitable for embedded applications not only dedicated to the only transport industry but switchable to different industrial sectors. This service chain is completed by an integration of specific software, job mostly done by local branches of national or international firms (examples: Dassault Systemes, SAP). On a next step, these companies provide and adapt these software to design, test and validate, according to the geographic proximity and close links they have with industrial customers, contractors or major subcontractors.

It is precisely among the diverse stratums of service providers specialized in developing software systems not necessarily linked to on-board systems, that emerge technology and methods which we will call « scattering ». They fit products and services in different application areas of on-board systems today with extensions to the branches of health, telephony and even home automation. In each sector area, on-board systems face the same types of issues, whether engineering, software, electronics, human interface system or diagnosis. The service providers then have the ability of developing transferable skills using an approach that covers multiple areas both in terms of technologies and markets. These services and expertise scattering from several areas of application include validation and independent verification of software and involve several local SMEs (Isoscope, Skylab, Artal Technologies ...). With the use of an expertise with contractors and system suppliers premises, these SMEs succeed in positioning and developing their activities on niche technology from a predominantly national broad customer base.

Other kinds of services and scattering cross-linked with the activities of on-board systems concern certification. This certification process is mainly run by a network of local experts « Certification Together ». After obtaining the recognition from the pole « Aerospace Valley » they offer training services and accompaniment for the preparation of certification audits.

These transversal skills structure the Toulouse cluster of on-board systems which is no longer reducible to a single industrial sector. Transversal skills are at two levels: first, through applied research with the involvement of various manufacturers, principals and system integrators on unifying research programs (eg program ISAURE) that stem from political Public (State of the Region), or are promoted by the cluster. On a second level, this movement is also a result from a traditional supply and demand process run by the market. Technology providers and SMEs with cognitive ability redeploy an offer and an expertise in a cross-sectoral model. In addition, the skills circulation is inherent in the metropolitan labor market: individuals carry with them their transversal skills. They are able to work in different industrial sectors (aeronautics, space industry, automotive electronics ...) or business technology services, whose activity is close to academic research, and move from one activity to another. Finally, these skills circulation allow the existence of a metropolitan labor market that is structured around these cross-cutting skills, such as architecture and engineering, electronic and computer systems. However, in the Toulouse region, the prime contractors and system suppliers remain specialized. Airbus is specialized in the production of aircrafts but it employs engineers in trades (qualification, validation, software development ...) that could work in space or automotive electronics. Therefore, the networking of the cluster is first made from the combinatorial capacity of SMEs and technology providers to build and manage expertise relationships with various industrial sectors and distinct markets.



Toulouse's Local System of Competence on « Software & On-Board systems » industry

Figure 1. Main links between organizations of the Toulouse's "on-board systems" cluster (Grossetti, Zuliani, 2010).

The services companies and the research laboratories are linked to all local principals, whatever sector they belong to. Engineers from services companies can work equally for a firm of space industry, aeronautics, automobile industry or even railway industry. In the same way, research laboratories can collaborate with all the firms, and graduates from local engineering schools can apply for a job in any kind of firm of the cluster. An engineer from a firm can apply to get a job in another firm in a different sector on the basis of his competence. The main common resources are knowledge and competences on the making of systems. Within the on-board system, the movements of the labour force are not necessary visible from the outside because they don't necessary involve a formal changing of job, especially when engineers of services companies shift from a mission for space industry to another for aeronautics for example. These movements and the more formal links result in a diffusion of technical innovations between sectors. Individuals changing jobs can be source of convergence of competences between the areas of activities. They also give the local economy more flexibility to face up to sector crisis, even if the aeronautics sector has much more employees than the others. We term this cluster « local system of competence » (LSC) because it is based on a kind of generic knowledge and competence and not on specialization of a kind of product or sector. As we saw, this LSC progressively emerged during the last 20 years from already existing more specialized clusters, mainly in space industry, aeronautics and electronics for transport.

The local system of competence is a result of long-term relationships between contractors, subcontractors, service companies, laboratories and start-ups created on the basis of technical innovations. These relationships are partly embedded in interpersonal relationships formed within higher education institutions or companies and maintained over changes in employment of people within the local job market (Grossetti, 2008). In particular, contractors often recruit engineers already working with them as employees of subcontractors and service companies. Once recruited, these engineers maintain ties with some of their original company. The embedding relationships between organizations in social networks and more generally in some kind of professional community is similar to that observed in the case of Silicon Valley (Saxenian, 1994).

In Toulouse and since a long time, the LSC of « on-board systems » has a formal political expression in local authorities and institutions. Engineers from companies or research institutes were elected as representative or mayors in many towns of the metropolitan area, and recently even in Toulouse itself. They are also involved in the local chamber of commerce and many other political places. In 1996, engineers from several companies and research institutes created the IERSET (European Research Institute for Electronic Systems for Transport) (Zuliani, 2008). The philosophy of the IERSET was to seek out synergies between the different applied sectors (aeronautical, automobile, space and railway…) and the applied research register. Its method of operation stems from experiences of collaboration between laboratories and industrial companies around problems relating to on-board computing and electronics. It expresses the will of the different actors to impulse a new form of collaboration. This approach, which was taken up by the local authorities and the Chamber of Commerce, brought other firms from the Midi-Pyrenees region interested by the same subjects, i.e. electronics and information technology for transport systems, alongside companies like Aérospatiale and Siemens Automotive. Moreover, the IERSET built up its activity by identifying needs expressed by industrial companies on specific, targeted projects which were organized and managed according to precise objectives. This private institution, with the statutes of an association but with a multi-sector character, pursued its objective of supporting programs of applied research into electronics and computing which would be transferred to all kind of transport (Air, Rail and Road). Acting as an interface and as a scientific and industrial lobby since the 1990's, this organization represents its partners by searching convergence in the technological dynamics of the aeronautical, space, railway and automotive sectors. This approach shows to a certain extent the maturity of the companies concerned with on-board systems as they give themselves the means to organize corporate governance by coordinating links between public authorities and the scientific community. Apart from the IERSET, research and development programs run on on-board systems involve a large number of organizations including other public and private bodies dedicated to the support and the finance of research activities (CNRT, GIPI, TOMPASS[5]).

In 2004, when the French government decided to create several « pôles de compétitivité », actors from LSC companies or institutes had good arguments for promoting an « on-board systems » cluser. As a result, they obtained the creation of a « pôle de compétitivité » orientated towards « Aeronautics, Space and On-board Systems » (AESE Cluster) at the inter-regional level between the Aquitaine and Midi-Pyrenees regions in the autumn of 2006. So, it seems that this « pôle de compétivité » is less the **cause** of the socio-economic cluster than its **result**. It is difficult to assess its effects. We made more than 20 other new interviews since its creation to better understand this.

In the field of on-board systems, firms (big principals like Airbus, Siemens-Automotive which became Continental, Thales Alenia Space or Astrium, big subcontractors like Liebherr Aerospace or Thales Aerospace and small very specialized companies like Intuilab or Serma technologies) participated in the making of the operation. Jean-Marc Thomas director of Airbus France, Jean- René Jecko, director of Thales Avionics in Bordeaux, and Jean-Marc Nozerans of Siemens Automotive (currently Continental) played a key role in the building of the operation. The above mentioned firms and their like were later strongly involved in the operation. Some of their members became coordinators of thematic programs, defining priorities and choosing the experts. The same firms made cooperative projects, sometimes with public laboratories, and asked money to the pole. To include local partners in the projects was one of the criteria for the assessing of the projects. The pole then financed several projects, some of them were already started as new ones too. Some projects involve several principals, and for a part of them, from different sectors. Services companies which are central in the LCS were weakly involved in pole's projects, except some of them (« Communication & Systèmes » for example) which already had a strong R&D activity. On the contrary, small transversal technological firms got involved in a lot of these projects. Figure 2 gives an idea of the projects and the collaborations involved. It concerns projects from programs « SSTA » (« Sûreté et Sécurité du transport aérien »), « NPT » (« Navigation, positionnement, télécommunications »), SE (« Systèmes embarqués ») et AI (« Architecture et intégration »). On the graph, we only show the links between leaders of the projects and partners.

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[5] CNRT: French National Center for Technological Research ; GIPI : "Groupe d'innovation pour l'industrie", a local club of entrepreneurs; TOMPASS : "Toulouse Midi-Pyrénées Aéronautique Espace Systèmes Embarqués".

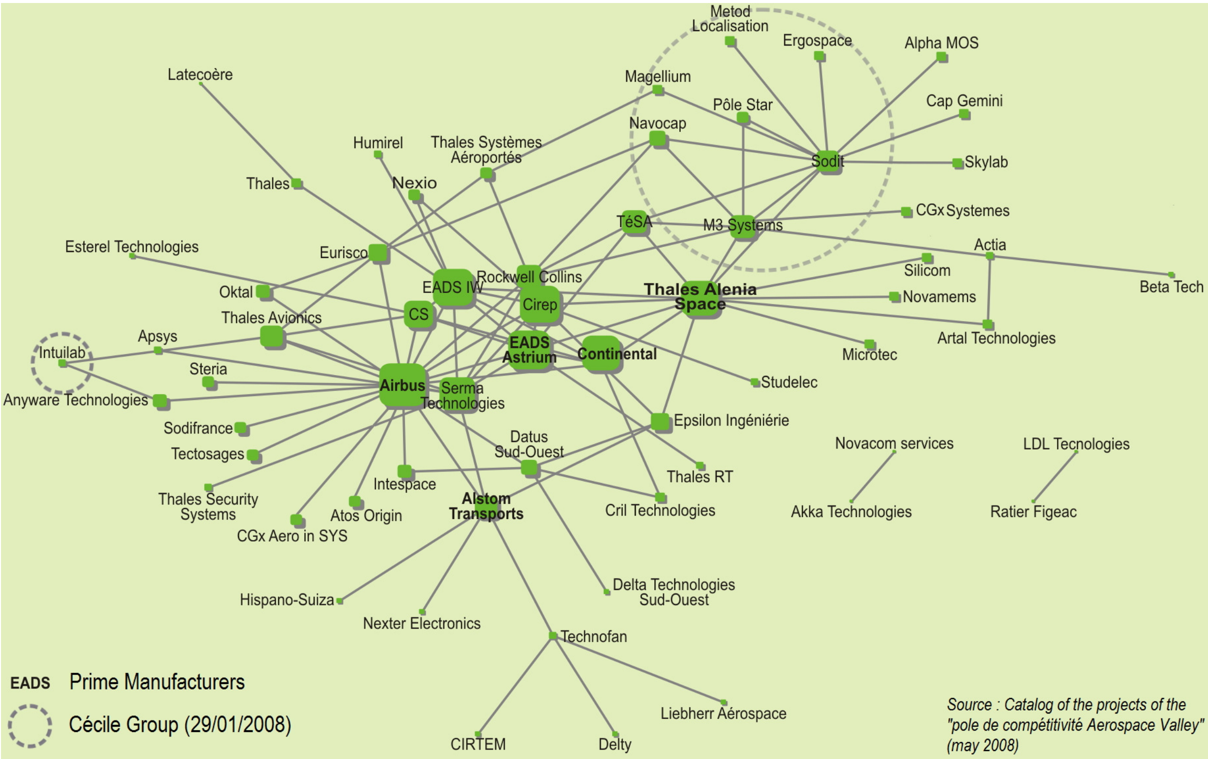

Figure 2. Collaborations in on-board systems program of the “pôle de compétitivité” “Aeronautics, Space and On-board Systems”.

It’s too early to estimate the mid-term and long-term effects of the operation, but we can make the hypothesis that it will certainly facilitate a stronger integration and an extension of the LCS, without modifying significantly its structure. The pole will also probably improve the technological level of big subcontractors, especially and at least, for some of them who had the opportunity to reinforce their R&D activity by hiring PHD students and increasing their cooperation with research laboratories. Some big subcontractors (Thales Aerospace, Liebherr), who weren't used to work with partners (other than customers or suppliers) and to share technical knowledge, had to experience this collaboration process thanks to the pole’s projects. Principals, who already were linked together by services companies and laboratories, created new direct links around the development of specific technologies that they will have to share in a second time. It will probably enhance the convergence of these technologies between different sectors and so, reinforce the integration of LCS. So, our global hypothesis so far is that the pole will only reinforce a system already running smoothly. To put it crudely, it seems that, so far, its effect is not negligible, but weak.

4 Conclusion

So, the Toulouse « on-board system » cluster is by no way the result of the current policy of the « pôle de compétitivité » « Aerospace Valley ». It’s the contrary: the « pôle de compétitivité » is the result of a pre-existing socio-economic cluster. The policy reinforce the socio-economic cluster but without modifying its structure. The socio-economic cluster is the result of two past policies, one local and the other national. The first one of these policies, in the beginning of the 20th century, was a failure regarding the ambition of creating a new hydroelectric industry but an unexpected success regarding the evolution of the local scientific pole. The second one, in the 1960 years was a success; even if this success took much more time to arrive: the idea of decentralising aeronautics schools was first formulated in 1956; the government decision occurred in 1963; the installation of the main school and of the CNES occurred in 1968; and the first results began to be visible after 1980. In 1974 several analysts thought that the decentralization was a failure...

In Toulouse's on-board systems cluster, private economic actors mainly use cluster policies as an opportunity to do the same thing that before with some additional money. Some actors (aerospace industry subcontractors) weakly connected with the cluster use the pole to better connect themselves to the whole local dynamics and networks already well structured. Some other actors (principals), which were weakly interconnected before, created more direct links and learn to work together for developing some specific technologies. Some firms (big subcontractors) are more involved in R&D activities. The sharing of knowledge is probably increasing and it's certainly more formally organised. The convergence of technologies in different sectors is probably increasing.

Systems technologies, most often highly critical, are the main skills transversal between industrial and scientific sectors. One of the characteristics of the cluster of on-board systems is its flexibility illustrated by the reorientation of the workforce according to cyclical fluctuations in the market (eg, space and electronics to the aerospace industry). Even if the cluster networking relies on the local labor market, which enables the movement of skills, and on engineering companies and technology services, it is not free from tensions generated by sectors. Indeed, differentiation remains between sectors using on-board systems. For example, the space industry is characterized by small series to be produced at the same time for which a high reliability is required, while in aerospace constraints related to security (with very demanding standards) prevail, the medium quantities to produce and cost trends downwards. In automotive electronics, and related on-board systems, quality constraints combine to produce large batches, and thus looking for low costs. The current general architecture of the cluster of on-board systems in Toulouse is characterized by the dominance of the aircraft sector, even though automotive electronics, the health and the energy production sectors gradually take advantage of this reallocation of powers between sectors. Within the cluster, tensions may arise between logics of sectors and logics of the dissemination of technologies. This draws more and more a regulatory role of public policies and actions undertaken by « competitiveness cluster ». If the trend favors the dissemination of technologies related to on-board systems to several industries, leaders of these policies also want each branch to be reinforced by the intrinsic logic of competitiveness.

The main results of the new cluster policies had the effect of strengthening an already existing socio-economic cluster. That case is an example of the strengths and limits of cluster policies as revealed by an analysis of the practices of private economic and scientific actors: when they work, it's often because they water already wet places.

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