# Extensive multi-domain innovation model through Aerospace Technology Adopter SMEs cluster; New Onera - The French Aerospace Lab development strategy

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## Introduction

Public research and development is considered one of the major sources for generating technological innovation and the concern of governments in major developed and emergent countries is to maintain high levels of resources and investments focused in this direction.

These investments have been sourced through public and private money so far to achieve a minimum targeted goal of 3% of their GDP, which is considered necessary, at least by the European countries, through their adopted Lisbon common agenda (European Council, Lisbon, 23-24 of mars 2000). It is well known that other countries like the USA, Japan, Finland, Sweden etc are already investing this amount yearly in their related R&D activities.

The aim of this paper is related to the strategic analysis of ONERA's new policy and implementing instruments for fostering innovation based on its aerospace technologies. Consequently, some of the well-recognized trends, in part induced by globalization effects, will be briefly mentioned to help place the technology transfer and industrial partnership tools developed by ONERA in the right context and environment.

## Part I: ONERA-The French Aerospace Lab's business operating environment; history, trends and induced strategy

### 1. Presentation of ONERA

ONERA is the national public aerospace R&D establishment in France. Its juridical status is as a public establishment with industrial and commercial interests. Its missions defined by organic law correspond to four main objectives:

- develop and direct aerospace R&D;
- conceive, build and operate test benches adapted to aerospace technologies;
- create added value through its research results applications to French national and European aerospace industries and eventually outside the aerospace domain;
- provide continuous training for students, PhD candidates and post- doctorate professionals through its coordinated research activities.

Onera's annual budget is based on approximately 40% direct subsidies from its tutor ministry, the French MoD; the remaining 60% being earned through commercial R&D contracts. Onera has the highest contract based activities/subsidized activities ratio within all French public R&D organizations. As we will see in the following text, this business model implies not only the existence of a performing commercial structure inside Onera, operating on up-to-date commercial tools specifically adapted to the French aerospace R&D market (and more generally to all the R&D domains), but also to Onera's organic law and missions. To better understand the newly implemented tools that enhance technology transfer from Onera to industry, a brief description of its operating environment is necessary.

## 2. Overview of general French public R&D

The large majority of public research in France was historically not oriented toward market applications. Generally, public scientists will prefer relative high degrees of freedom in the choice of the subjects they investigate. Performing research on a contractual basis with an industrial is perceived more as a constraint and not as an accelerated way for market implementation of their results **[1]**.

This 'cultural barrier' was also indirectly encouraged and maintained by the historical strategy of public research at national level. For example, most of the universities were not structured to perform applied research and to have partnerships with industry. This role was given historically, and until now, to the National Institutes or Centers.

Until 1999 and the passing of the law Allegre **[2]**, few of the French universities had commercial and legal services structured to deal with technology transfer, or to promote and sell scientists' expertise or research results. This issue was well addressed by the above-mentioned law and nowadays the majority of the technological universities possess these types of services.

A new law regarding public universities was proposed in 2007 **[3]** with the aim of completing the development of universities by linking them with major industry and other economic players, providing the environment to better respond to economic market needs, in terms of more appropriate education for students. It will also introduce the "customer voice" inside the university science community. This should encourage an active policy, which will favor applied research activities and respond to identified industrial needs.

## 3. New trends and mechanisms

Recently, with governmental positive pressure and support, public research organizations at top management level are beginning to look at creating value from the know-how, expertise and IP generated in their laboratories. Recently, two mechanisms were implemented with government support and this is reshaping the overall French public R&D system. We will further briefly introduce them here.

### 3.1. Competitiveness Poles

The idea of 'Competitiveness Poles' are based on the effect of agglomeration in a given geographic area. Some of the positive effects were stimulated with the creation of regional clusters. The state (through a common inter-ministries' fund) and the region, will finance only consortia with increasing economic efficiency through R&D partnerships among all regional actors **[4]**.

The financed projects must involve main industrial partners (which generally will be the end-users), R&D capacities (could be university labs, national institutes and private engineering companies) and small and medium-size enterprises (without such participants, a consortium chances to obtain financial support dramatically decrease). Such projects will help integrate the supply chain of the main industrial partner. As we shall see in the following text, this will have a very positive impact on the current supply chain rationalization policy driven by the main industrial groups. Consortium members will receive partial funding according to their juridical status (private or state-owned), their cost structure and their size (the main industrials will receive less support in comparison with SMEs).

With no doubts about the positive effects that this new mechanism will induce inside the French public research community (mainly, the obligation for a partnership driven by industry and so the development of "market-driven" research) some negative effects may occur, such as;

- greater difficulty for a non-regional company to integrate a consortium, even if its competencies and knowledge are not represented in the geographical region;

- lower possibility of occurrence of innovation generated through “cross supporting knowledge” or “connect& development” processes with other domains with no contingency with the one of the specialized Pole.

### 3.2. Carnot Institutes

In 2006, the French Research and Education Ministry introduced the new Carnot label as a recognition and financial award for public R&D capacities which generate parteneurial research with industry **[5]**, **[6]**. Qualification of the institutes for this label is based on their annual budget obtained through contractual research with industries. For the following year, respective institutes will receive a grant based on their contractual revenues, with the only condition being that this money must be allocated for technological and scientific re-sourcing.

The purpose of these new generated R&D projects must be to obtain new R&D contracts or financial return from the industry within the next 3-5 years, thus creating the link between basic research and product-based applied research and/or bringing the level of technologies inside the research labs from TRL **[7]**, **[8]** level 3-4 to level 6.

So far, 33 institutes have been recognized as being Carnot institutes. Representing 12% of the French Public R&D population, they employ 12,800 people and generate 470 million euro annual revenues on a contractual basis with the industry.

This provides substantial evidence of the “picture” description made earlier in this chapter. These 470 million euro represents 50% of all contractually-based applied research that the whole French public R&D organizations carry out annually with the industry. The 33 Carnot institutes have an annual turnover of about 1,300 million euro. Their activity is, on average, based on 36% R&D contracts with industry and the remainder is shared between fundamental research with direct government subsidies or applied research on public programs and contracts. On average, about 10% of this contractual research is conducted with, and for, the benefit of SMEs.

## 4. Aerospace R&D specificity

Onera is currently operating in this environment where performing applied research on contractual basis with the industry is not the dominant way of carrying out research activity.

In addition, aerospace R&D is still considered, and not only by France, as being strategic for national interests. However in this changing environment of R&D becoming global **[9]** and with R&D outsourcing and strategic alliances **[10]**, ONERA is facing fast changes within its historic business operating environment.

Some key Onera’s strategic R&T partners are globalizing their R&D strategy. Airbus opened engineering offices in Moscow and Beijing. Thales has a R&D centre in Singapore and several in China. Snecma (Group Safran) presents an annual award for the best PhD they sponsor in China.

Within this fast-moving environment, Onera made the choice to highlight the provision of return on innovation for its partners. This emphasis comes with strong management support and boosts innovation as a major business development objective. We aim to enhance our innovation paths to create value for all the stakeholders and to sustain competitive advantage.

The first issue we strategically faced was provided by the aerospace specificity in performing, or adopting, innovation. The figure 1 showcasing the limit of its ability to follow an innovation by the technology creator itself (**[11] completed with different limits by the**

**authors**), clearly demonstrates that the linear model of innovation is not well-adapted to the aerospace sector.

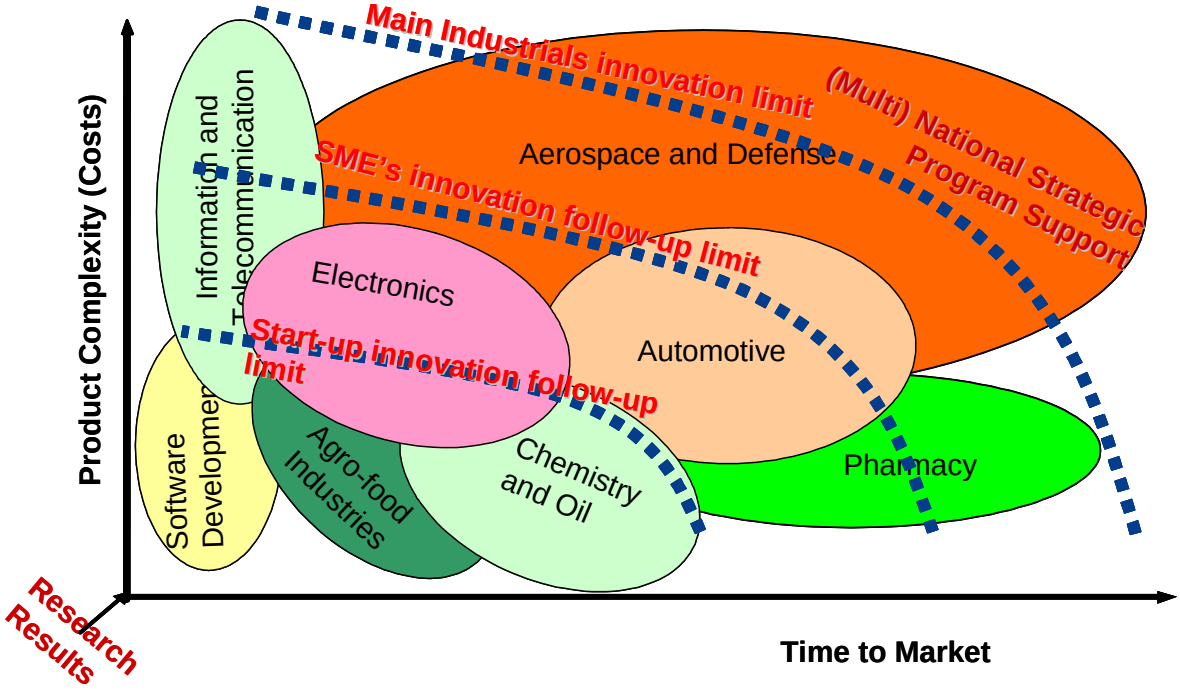


*Figure 1 - Limit of its ability to follow an innovation by the technology creator itself*

The long cycles of developments as well as the high level of complexity in the aerospace products (or systems) induce a high risk for technological investments. This, together with the required level of security and liability in the aerospace domain, does not favor easy adoption of new technology.

This difficulty, so specific to the aerospace industry, to follow-up an innovation process is also valid for a large company which has a numerous targets on the run. Outside of their core business innovation process, they would generally tend to prefer to buy a proven technology and so prefer to leave a start-up to prove it (**McCooe, 2002, cited in [12]**). In particular, this type of approach provides few chances for a breakthrough technology to emerge in the conservative aerospace world through the classic model of the "entrepreneur as the driving force of the innovation" (Schumpeter theory **[13]** studies presented in **[14], [15]**).

With no strong support and no possible direct start-up policy for aerospace market (except a few niche market products), ONERA was more likely to function in the co-innovation partnership strategy **[16]** by making a strong technology push together with the industrial partner to orient and obtain support from the national public aerospace programs.

By comparison to the beginning of activities at the Columbia Innovation Enterprise **(McCooe, 2002, cited in [12])** when CIE dealt almost exclusively in large corporate licenses and offered no assistance to start-ups, ONERA historically - and until now – almost exclusively dealt with leading aerospace industrial groups mostly on R&D contracts with few IP valuation.

From our traditional business model based on providing premium solutions to the French and European aerospace industries through R&D contracts, we start to integrate all the "3-Totalities" constructing the "total innovation management" model **[17]**; all elements of the

business operating environment, all involved individuals and all time and space to generate new sources and paths of innovation using our technologies.

We redefined our strategic partnership policy with our main industrial partners; we actively search for collaboration processes with SMEs, mainly to create technology demonstrators irrigating other domains or niche aerospace markets; and we also promote technology transfer by spin off and start-up creation and/or support.

## Part II: Method, adopted tools and early-stage results

A set of tools already existed in the relationship Onera held with its employees, its industrial partners and its academic research partners. We will further describe, through related chapters, all the involved actors of the innovation chain generated by Onera's technology and we will showcase, wherever necessary, their interactions inside one of three "Totalities" of the Xu model **[17]**.

### 1. Evolution of strategic collaboration with our main industrial aerospace partners

Our major concern was to capitalize on the historical relationship ONERA had with the major European aerospace industrials. Since 2005, strategic partnerships are including renewed and improved co-innovation rules **[16]**. There are also mechanisms to teach us from our technology users; "lead users" concept such as **[18]**.

As an example, Airbus adopted Onera's computer software eLSA as a strategic software for their R&D teams. During the last few years, their researchers developed additional models for aerodynamics which were introduced and integrated by Onera teams. A new stage in the partnership related to this specific software was made when Onera entered into the private equity of CERFACS, a common development computing laboratory owned also by Airbus, Snecma and other R&D organisms.

The new strategic partnerships were built along the following main principles:

- exchange, with full confidentiality, of strategic orientations between the parties
- commitments from both parties for exploitation of common results within the industrial partner field of activity
- fair financial return for Onera based on exploitation of its technology by the industrial partner.

### 2. Evolution of spin-off and spill-over policy

The second major concern was to enhance technology transfer to existing SMEs, or by appropriate spin-off policy. By experience, these activities occurred mostly outside the aerospace domain.

It was proven that changes in the R&D institutes or university culture to support technology transfer can significantly increase the number of spin-offs over time **[12]** and it is well accepted that start-up companies are more likely to locate in proximity to the licensing institution to better capture and assimilate the benefits of subsequent emerging technologies**.** From our recent experience, all the start-ups licensed on ONERA technology are located at less then 10 miles from one of the Onera's centers.

These two considerations stimulated us to organize yearly 'Aerospace Technology Day Conventions' in the regions where we are located through our centers in France. These conventions were generally shaped for local SMEs to promote the benefits they could have by working with Onera researchers. They had as participants, local authorities and innovation support structures.

The major issues we face working with SMEs is their weak cash disposal capacity. Indeed, medium-size companies barely exist in France. Available data **[19]** shows that the representative company in France is more likely to be considered a small enterprise (less then 50 employees) **["small companies remain so" in 20]**. How does one develop a technology transfer program with such a company?

| Number of employees | Less then 20 employees | From 20 to 49 employees | From 50 to 99 employees | From 100 to 249 employees |
|---|---|---|---|---|
| Number of enterprises | 129 400 | 12 800 | 4 100 | 2 800 |

Existing mechanisms to financially support R&D made by SMEs are still not well adapted to the small size characteristic of French SMEs. As an example, the national agency for innovation support, Oseo-Anvar, could only help with guarantees and a 50% refundable advance, far from sufficient for such an enterprise of such size to support investments of 700 k€ euro in technology transfer programs (the average amount engaged by ONERA's SME partners) aimed at helping introduce a new product into a market, or create a new market.

The regions, subjected to local policies, could help with subsidies restricted to 50% and generally with a limited amount. The EU could also sponsor 75% of R&D activities but the time necessary for decision-making encourages this support only for "far from the market" R&D projects.

### 2.1. New ONERA-SME charter

We emphasize that figure 1 proves that SMEs are the best adapted vector for spill-over technology demonstrators generated from our aerospace research results. The above mentioned considerations showcase the financial barrier identified in France, due to the small size of French SMEs and to the financial public support instruments still not adapted to this specific size.

Our proposed solution is based on a collaborative charter we have conceived and signed with more then 60 SMEs over the last year. We currently have a monthly average of four to five new SMEs signing the charter from various domains and regions.

This charter has four mains objectives:

- favor access to aerospace & defense R&D results;
- favor emergence of innovative proposals;
- foster commercial contract opportunities;
- compliance with Onera's mission of supporting the industry.

Based on a win-win relationship for targeting technology markets and on the important cultural gap between our "public French scientist culture" and SMEs' characteristics such as speed, efficiency and simplicity, we identified the following benefits:

<u>- mutual benefits</u>

- reinforce our competitiveness through complementarities of skills:
  - to win contracts on the R&D market
- to propose alternative solutions, in particular for technology demonstrator projects.

<u>- benefits for SMEs</u>

- access to scientific expertise, tools and solutions from the aerospace domain;

- opportunities for technology and transfer of know-how for new products and businesses;
- opportunities for hosting an ONERA spin-off;
- reinforce competitiveness of SMEs with high added-value scientific inputs;
- reinforce SME's visibility in the aerospace market;
- promotion of SME's on ONERA's website and in national and international communication and commercial operations;
- a boost for innovation.

- benefits for ONERA

- faster implementation of research results into the market by SMEs;
- improvements in customer/market culture inside the organization;
- facilitation of applied research through collaborative projects;
- complementation of ONERA's scientific offer with reactive, flexible, lower cost contributions.

We specifically targeted SMEs or start-ups with the following characteristics:

- core business in synergy with ONERA;
- ability to integrate technology/know-how from ONERA;
- innovation champions (R&D > 8% of annual turnover),
- no minimum size or age but financial sustainability.

Finally, we identified and proposed five collaborative issues to our SME partners:

- partnership on R&D contracts from common public or private clients;
- technology and/or know-how transfer from ONERA to the SME;
- products/services risk sharing co-developments;
- ONERA's scientist eventual transfer into the SME's development team when licensing a technology;
- SME access to ONERA's expertise, test facilities, computing and simulation solutions.

The risk sharing co-developments contract represents by itself an innovation inside the public French R&D environment. After economic analysis (business plan, market study, etc), ONERA can opt for taking in charge partially, or totally, the development costs corresponding to its own work within the frame of a common development project. The financial return for ONERA will be provided by annual negotiated deferred payments based on the successful exploitation of the SME's products/services.

### 2.2. Spin-off for Spin-in Onera's employees charter

One of the issues to address was the very few number of ONERA scientists who launched start-ups. The explanation is more likely to be a question of environment and lack of business experience. In addition, our research activities do not facilitate research projects getting to a TRL higher than 4 and this correlated with the poor activity of 'Business Angels' in France **[21]**, considerably increase the risk when launching a start-up.

These considerations fully justify the lack of start-up creation by ONERA's scientists. The most experienced way (like the one described by **[22]**) at ONERA to create start-ups is the one where an external and independent agent assume the role of entrepreneur while the technology originator maintains a role within the institute.

The difficulties of raising money for a "first-round" - so specific in France - encouraged us also to actively support licensed start-ups to raise money for needed development. We are currently deeply involved in networking with all regional organizations providing innovation

support. In addition, as McCooe showcased for Columbia **[12]** some of our licensed start-ups obtained money from outside the country.

To stimulate our scientists' entrepreneurial initiatives our 'Spin-Off Charter' was re-adapted. Its main principles are based on up to three years guaranteed return for the scientist in a similar position, and some level of financial ONERA support. Despite this charter, we registered only one departure for each five years on average for the global population of the 2,000 employees that ONERA has. Only strong individualities with managerial skills "dare the adventure".

The reason of this low spin-off ratio was identified as the perception that the scientists felt very insecure from a social point of view when creating a start-up. The solution we found was to offer this "security" by transferring the technology to an existing SME in external growth need. The scientist transfer inside the SME's development team, while licensing an ONERA technology was thus identified as the best policy to enhance technology transfer.

The only remaining issue was how to measure the true interest from SMEs to adopt ONERA technology. We considered the best indicator for measuring this particular interest was to encourage the SME to open its private equity, with a minimum of 5%, to our spin-off scientist(s), the technology creator(s).

The new 'spin-off employees charter' at ONERA thus became a 'spin-off for spin-in an SME charter' too. From this standpoint, we applied the same conditions for the two cases.

### 3. Early stage results

The new introduced mechanisms have generated until January 2008 more then 60 Onera-SME charter signatures from various companies. The http://innovationhub.onera.fr is presenting all the partners as well as their specific competencies. About 10 of them were already in various relations with ONERA when the Charter was implemented. About 20 of them are in a licensing relation with Onera, another 20 of them are focusing on a common R&D project and the rest of them are actively searching to create a cooperative project. The table below gives a short list of selected (for their variety) companies and their respective relations with Onera.

| **Company name** | **Application** | **Collaboration type** |
|---|---|---|
| Leosphere | Wind LIDAR | License, common R&D, and scientist spin-out |
| OKTAL-SE | Electromagnetic Synthetic Environment Simulation | Software license and common R&D projects |
| Phasics | LASER interferometer | License |
| Protip | Start-up on bio-medical prosthesis based on porous Ti technology | License |
| Ixsea | Inertial Navigation | License on accelerometers |
| Sirehna | UAVs and sailing | Common R&D and license on Fluid Simulation software |
| Satimo | Medical Imagery | Common Development Program |
| Agilite | Pollution detection | License on sensors |
| Isitek | Domestic welfare surveillance | License on sensors |
| Microcertec | Ultrasounds ceramic machining | License |
| Fogale-nanotech | Capacitive Sensors | License |
| Andheo | Fluid Mechanics and Energetics | License on Onera's software |
| Sofratest | Fluid flows measures | License |

| | | |
|---|---|---|
| C3EM | Crack tracking and detection and acquisition instruments for wind tunnels | License, Onera's Wind Tunnel Supplier and Common R&D |
| Secapem | Real time scoring and targeting system | R&D common project |
| Mapaero | Pressure Sensitive Paintings | License |
| Focus21 | Ground Effect based aircraft | Risk sharing development program |
| ACV Aeroservice | Green airplane | Risk sharing development program |
| Nheolis | New wind mill concept | Risk sharing development program |
| Keopsys | LASERs | License |

The first successes from cross-supporting competencies and the first successes from spill-over technology transfers among various other domains like bio-medical, health surveillance, automotive, pollution emissions, accurate LASER optics... have generated increasing interest from all ONERA's stakeholders (Ministry, Regional authorities, venture capitalists, etc) and mainly from the prime aerospace industrials for the technology demonstrators obtained by the Onera's SMEs partners in other domains.

They all understood that using ONERA's aerospace "originated for" technologies, they could develop innovative solutions with strong market success impacting regional economic development wherever ONERA is present with its 8 centers throughout France.

The success generated with the Onera-SME Charter among the SMEs introduces and recognizes not only ONERA's leading role as a major source of innovation by bringing together all innovation path stakeholders, but also ONERA's technology transfer policy as a bolstering process providing a cluster of talents, knowledge and multi-domain innovation. This leading role for a regional R&D capacity was also identified by other researchers **[23], [24]**.

## Part III: Perspectives

We will further introduce some considerations about the recently observed impacts of the Onera's innovation strategy at micro, meso (domain and regional) and macro economic level.

### 1. Micro-economic impacts

At the microeconomic level, Onera's innovation strategy is generating changes in the internal organization of the institution. Focusing on larger spectrum of potential clients and in sectors different from its core business (space, aeronautics, defense) the traditional organization of the research departments could be perceived as a barrier in developing spin offs, involving researchers in the innovation process with SMEs and in increasing the number of licenses by useful inter-departments team work.

The traditional evaluation of the departments' performance is pushing the public institutions to focus on single domain objectives, serving just the traditional big French companies, now multinational companies, instead of taking into consideration the opportunity of technology transfer in multiples sectors thank to the dynamism of innovative French SMEs.

The "researcher" role is also enriched in responsibilities and opportunities. The multidisciplinary comprehension offers to researchers a better chance to get involved in multi-sector research. Apprehending managerial and marketing skills and knowledge from the SMEs teams, gives the scientists the opportunity and willingness to spin off (1/year spin-off

scientist departure to be compared with 1 departure / each 5 years before the new strategy implementation).

Thus, training and communication is crucial for understanding the benefits of the Onera innovation model for the researchers and for the profession in general in order to change the stereotype of researchers and thus attract more young people towards dynamic jobs created in the research sectors.

The new relation with the client is a cooperative one and this “co-conception” process, together with the client, is central for the success of the technology transfer towards the SMEs. The time spent by the client’s team and Onera's team to co-develop the new product/service is a productive time accelerating the successful technology transfer process. The institution must recognize and encourage this productive time bolstering this cultural change inside the organization.

**2. Meso-economic level (relation with local actors: relation between the institution and the local actors, regulation policies)**

The evolution of the targeted clients from a single specialized sector (aeronautics and defense) to the multi-sector approach, associated with the evolution from serving big industrial companies to also providing high added value research to French SMEs attests of a new positioning of ONERA and of a redefinition of the relations with partners and clients.

ONERA innovation model, together with other considerations, is currently generating changes in the local institutional structures regulating the innovation financial support and in the relations between local authorities, governmental structures, local education institutions. Nowadays, Onera’s business development top level executives are invited and actively involved in several working groups on defining, by sharing good practices, innovation public policies reforms to be implemented at regional and national level.

Onera intervention on multi-sector innovation, based on research results from the aerospace sector, could place itself in a competitive position with traditional R&D providers in the related specific topics. This has an impact on “competition forms” (“price”, “quality”, “innovation speed”) and Onera is advantageously capitalizing on its multi-disciplinary research capacity.

The new competition form “multi-sector innovation” in the Onera model is important in relation to the access at public investments. Onera, teaming with the appropriate partners from its SME partners cluster, will thus be able to compete for governmental technology demonstrator programs. This could induce a fair competition with its own strategic main industrial partners on certain programs.

More than this, ONERA’s innovation strategy responds to the problems faced by the clusters model which is based on agglomeration and specialization effects **[25]**, model proved to be risky on a long term because of the exaggerated specialization and the lack of diversification on jobs, sectors, competences in this “small worlds” **[26**].

Onera innovation model is basing its positive impact at local level on complementarities effects and interactions **[27]** encouraging SMEs working in complementary sectors (not necessary included in a Competitiveness Pole **[4]**) to develop innovative products and services based on a diversified functional use of licensed aerospace generated research results.

Onera, by its new strategy of technology transfer towards SMEs, is also playing the role of distant source **[28]** of novel ideas and expertise for the French Competitiveness Specialized Poles in different other sectors from aerospace. Thus, the SMEs are not only depending on internal interactions within the Poles to get access to R&D resources, but benefit from outside

(in terms of geographic and/or domain proximity) knowledge inputs to generate innovation. This consideration is valid too for an isolated SME (without relationship with a specialized Pole).

### 3. Macro-economic level: global economy changes

Onera innovation strategy is highlighting the positive role the public research could have on the competitiveness of the French SMEs and generally on the jobs creation. On a long term, this will have a positive impact on the attractiveness of the public research sector and will change the mentality from a "pure fundamental scientist" mind to a "solution oriented" mind in France.

Economists studied the conditions and impacts of financing innovation and its relation with the economic growth. The "information asymmetry" was identified as one of the major factors weighting on the financial risk while supporting innovation **[29]**, **[30]**.

Two of the Onera's new propositions implemented in our TT policy, the new Risk Sharing Development Contract and the scientist spin-out for SME's spin-in, are considerably decreasing technological and economic uncertainties and boosting chances of success. The proposed co-innovation process reduces the technological information asymmetry through a common technical working program agreed between the parties: this is thus also reducing uncertainties for financial investors in the innovative project.

### References


1] Rapport sur la Valorisation de la Recherche, Inspection Générale de l'administration de l'éducation nationale et de la Recherche, N°2006-82

2] Loi n°99-587 du 12 juillet 1999 sur l'innovation et la recherche - NOR: MENX9800171L

3] Loi n° 2007-1199 du 10 août 2007 relative aux libertés et responsabilités des universités - NOR: ESRX0757893L

4] Article 24 de la Loi de finances pour 2005 n° 2004-1484 du 31 décembre 2004

5] Loi de programme n° 2006-450 du 18 avril 2006 pour la recherche - NOR: MENX0500251L

6] http://www.instituts-carnot.eu

7] Technology Readiness Levels, A White Paper, april 6, 1995, John C. Mankins, Advanced Concepts Office, Office of Space Access and Technology, NASA

8] http://sbir.nasa.gov/SBIR/sbirsttr2007/solicitation/appendix_B.pdf

9] Tucker, R. B. (2002). Driving growth through innovation: How leading firms are transforming their futures. San Francisco: Berret-Koehler Publishers inc.

10] Chen, J. (2002). The Challenge of R&D globalization and the management task. Management Review (Chinese Journal, 11), 50-55.

11] R. Stephan, Université de Compiègne, « Which practices for universities to enhance exchanges and transfer », presentation at the French American Foundation seminar "Research & Innovation: Best Practices for the Future" Paris, 2006-11-27

12] Elyse Golob, Capturing the regional economic benefits of University Technology Transfer: A case study, The Journal of Technology Transfer, vol 31, N°6, 2006, pages 685-695

13] J. A. Schumpeter (1934). The theory of economic development. Cambridge, MA: Harvard University Press.

14] C. Freeman, et all (1988). Japan: A new national system of Innovation? In "Technical change and economic theory", (pp.330-348). London: Printer

15] R. Rothwell, (1992). Developments towards the fifth generation model of innovation. Technology Analysis and Strategic Management, 4(1), pp 73-75

16] S. M. Shapiro (2001). 24/7 Innovation: A blueprint for surviving and thriving in an age of change, New York: McGraw Hill

17] Xu Q & all, TIM (Total Innovation Management) – A novel paradigm of innovation management in the 21st Century, Journal of Technology Transfer, 2007 vol 32, N 1-2, pp 9-25

18] E. von Hippel (1988), The sources of Innovation. New York: Oxford University Press.

19] http://www.insee.fr

20] P. Renaud, Oseo Innovation, "Open Innovation at Oseo Innovation: Example of the Passerelle Programme" presentation at the OECD Business Symposium on Open Innovation in Global Networks, Copenhagen, 25-26 February, 2008

21] Grégoire Postel-Vinay, MinEFI/DGE, Chef de l'Observatoire des Stratégies Industrielles, *Business angels, satisfaire au désir d'entreprendre ; les "gazelles" un enjeu stratégique pour la France* - Conférence à la société des anciens élèves des Arts et Métiers, 27 mars 2006

22] S. Franklin, M. Wright, 2001, "University Spin-out Companies: Academic and Surrogate Entrepreneurs" in W. During, R. Oaakey and S. Kauser (eds.), New Technology Based Companies in the New Millenium, New York: Pergamon

23] H. Etzkowitz, 1999, Bringing the Gap: The Evolution of Industry-University Links in the US, in L. Branscomb, F. Kodama and R. Florida (eds.) "Industrializing Knowledge: University-Industry Linkages in Japan and United States", Cambridge: MIT Press.

24] R. Florida and W. Cohen, 1999, Engine or Infrastructure? The University Role in Economic Development in L. Branscomb, F. Kodama and R. Florida (eds.) "Industrializing Knowledge: University-Industry Linkages in Japan and United States", Cambridge: MIT Press.

25] A. Weber, « The theory of industrial location » 1909/1929, University of Chicago Press

26] Watts, D.J. and Strogatz, S.H. (1998) « Collective dynamics of « small-world » networks », Nature 393 (6684)

27] Zimmermann, Jean Benoit, " Grappes d'entreprises " et " petits mondes " Une affaire de proximités, *Revue économique*, Vol. 53, No. 3, Développement récents de l'analyse économique: Le congrès annuel de l'Association française de science économique 2001 (May, 2002), pp. 517-524

28] Maskell P, Bathelt H. and Malmberg A. 2005, "Building Global Knowledge Pipelines: The Role of Temporary Clusters", World Development, No9, pp 1715-1734

29] G. A. Akerlof, The Market for "Lemons": Quality Uncertainty and the Market Mechanism. The Quarterly Journal of Economics, Vol. 84, No. 3, 1970, pp 488-500

30] Stiglitz, J and A. Weiss (1992). Asymmetric Information in Credit Markets and Its Implications for Macroeconomics. Oxford Economic Papers, 44, 694-724