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Combination of CP & CSA

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D6.1 – Guide on technology transfer issues for R&D partnership

Version 2

Florin Paun (5 – ONERA)

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1. Executive Summary

This guide for technology transfer is specifically addressing the EUFAR scientists' community. It first showcases the operating existing markets and the long time to market (10 years+), specificity to successfully implement a new technology. This long time to market induces a specific cultural mind-set which needs to be compensated through specific training of scientists, familiarising them to the innovation challenge.

It is also highlights that the users of the EUFAR community research results include other non-EUFAR scientists. Thus, the EUFAR scientists will not necessarily have direct contact with the current operators on existing markets such as the Meteorology or Aircraft Manufacturers/Operators, complicating even more the technology transfer of their technology/competency. Some expected markets such as pollution detection and climate change are also recalled.

After a brief description of the actors and the identified/proposed paths to innovate, this guide particularly insists on how to proceed on carrying out a successful technology transfer process and details the actions to be conducting, starting with the training of the scientist and those related to the 3 identified/proposed Paths to Innovate; use of data, connecting directly with operators and cross sectoral applications.

2. Introduction

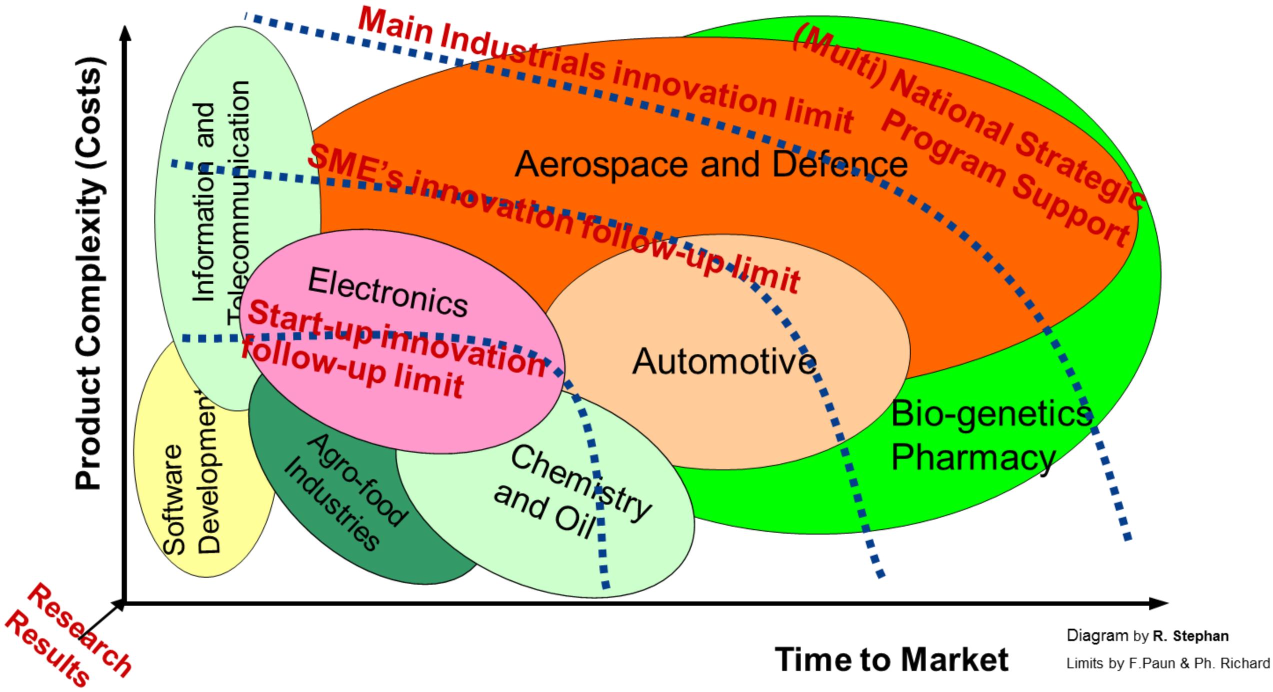
The Technology Transfer process aims to create value from research results by introducing innovative products/services, based on the respective developed technology/competency, into an appropriate market. These new innovative products/services will be successfully sold only if they will create new competitive advantages in comparison with the existing ones. Thus, this process of the technology transfer is based on 2 main pillars: the technological competitiveness in comparison with the existing products/services and the fulfilling of an existing demand on a respectively targeted market.

The necessary condition to the success of such a Process of Technology Transfer is the effective collaboration between all the involved parties. Indeed the creators of the Technology/Competency, the scientists from the EUFAR members, etc., will have to work together with the industrial engineers in order to allow them to implement, in the best manner possible, the transferred technology/knowledge on their industrial production chains. These "doers" will need to collaborate with their sales representatives and marketing officers in order to comply their new product/services with the final needs of consumers.

3. Specificity of the EUFAR members

3.1. Markets

The following figure showcases the capacity of the creator of a new technology to implement this new technology in a market. The markets are pictured as a generic bubble with no need for their precise contours. We could see thus, that for the software development the level of complexity is not necessarily high but the time to market could be reduced to only 6 months. When we are speaking about new generation of servers or devices for telecommunications, the level of complexity will be very high but the market still requires a new generation almost every year. Thus the average time to market will be around one year.



Specific for EUFAR members this figure particularly highlights the long time to market possibly >10 years for some niches of the aerospace market in which EUFAR members are currently operating. This long time to market induces a cultural mind set among our scientists which makes them focus on producing the best knowledge expertise related to atmospheric measurements but reduces their motivation to transfer this knowledge because they simply do not know what the market entails being so far from it. Additionally, this market is strictly ruled by an important set of specific norms experienced during the past few years due to strategic security and safety reasons, amongst others. This definitely induces into the mind of our scientist a kind of “barrier” when speaking to them about market constraints/ requirements, and their perception of the subject is more linked to a kind of restriction to their liberty to create knowledge so far…

The ***Users of the Results*** produced by our scientists involved in atmospheric measurements are scientists (mainly their own colleagues often inside the same institutions) building predictive models related to the dynamic of the atmosphere. These models will serve mainly in two major markets: Meteorology and Manufacturers/Operators of various aircraft.

Meteorology is potentially an important commercial activity but is also a component dedicated to common wealth (by providing warning for storms, thunderstorms surveillance, volcanic ash…). The market for meteorology is already settled and no new incomers appear (important barrier to possess an adapted infrastructure) but… we could bet that the internet of things through connected micro meteorological stations (watches, personal trainers, drones, etc.) could blow the current existing business model…

Manufacturers/Operators of Aircraft need knowledge about the atmosphere in order to define, conceive and predict the behaviour of the various aircraft they build/operate (such parameters include aerodynamics, lightning strikes, engine behaviour…).

Other markets identified, such as the one dedicated to the pollution survey, which unfortunately seems to be not large enough for assessing, preventing and monitoring but operates rather under "stress" conditions and is quite solicited in cases of accidents and dangerous pollution monitoring and effects constraining…

Another expected "market" will be the one dedicated to "climate change". Unfortunately for the moment we could perceive a lot of "nice wording" but there are very few investments from the market (only public money to monitor and survey). The introduction of constraining norms such as the correct pricing of the CO_2 will definitely develop such a market for EUFAR member, but until such time, we will not dedicate a specific guide to transfer knowledge on this non-existing sector as a market. The ongoing discussions on setting a common governance for the EUFAR community under an AISBL (Belgian law type association) grant that, once the right moment has arrived, the community will know how to handle this new market sector (and even to preview the future developments in it).

3.2. Actors and Paths to innovate

Path to innovate ***number 1 – use of data***. We could observe that from the use of data perspective, to reach a market, our EUFAR scientists depend on the other non-EUFAR scientists (often their own institute colleagues) researching, by predicting through models, the atmosphere characteristics and behaviour in a given time. These ***colleagues are consuming the data*** generated within EUFAR. They will "see" the other actors operating in the market, thus are positioned as an ***interface*** between the EUFAR scientists and these actors operating in a specific given market, however needing and using the results produced by our scientists. This path to innovate is definitely an ongoing path and the knowledge produced by the EUFAR scientist is already reaching the market following such an implicit collaboration.

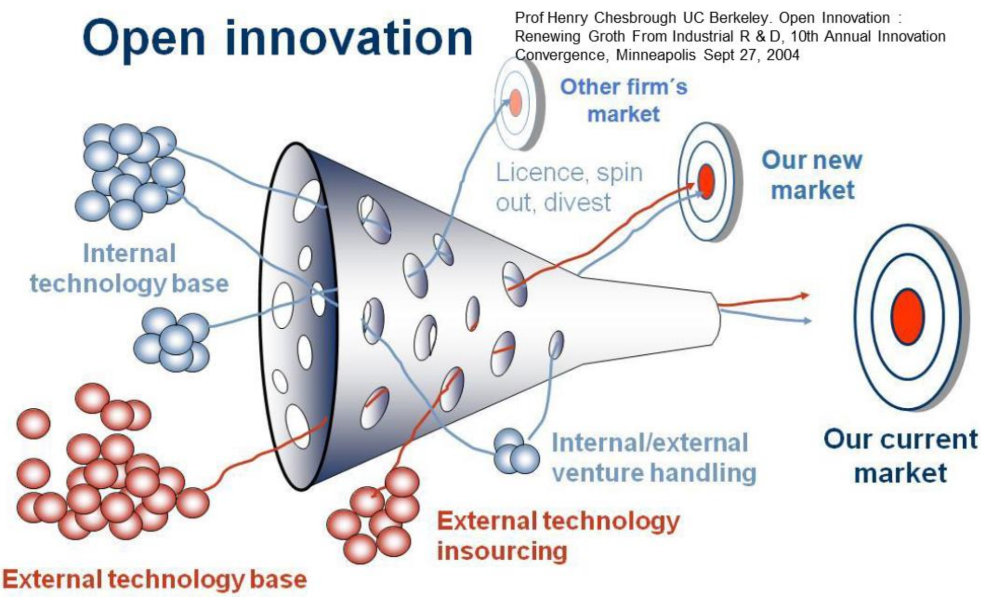
If the European Commission wants to highlight and measure more accurately such an impact provided by this type of Technology Transfer, we need to define partnerships and implement indicators with these type of ***"data consuming" scientists/colleagues*** and their specific Commercialisation/Tech Transfer Office, often the same unit inside the same institutions, for the use of these data, when this usage will provide added value commercially.

Path for innovation ***number 2– Connect directly with the operating actors*** within a given market known and served by the ***interface data consuming scientists/colleagues*** to promote real-time measuring devices when predictions are less interesting/ useful than real-time monitoring (e.g. icing and defrosting devices, anemometers…). From the successful experience (see example of Leosphere below) of some of the EUFAR members, we could note that providing measurements aiming to install a productive device is feasible while monitoring the same measurements in real-time to operate the same device is not so easy, being considered as a critical core competency by the final user. The preference is for a vice versa situation while installing an accident prevention device (e.g. defrosting devices).This will induce from a Tech Transfer perspective careful attention, while transferring sensors or measuring devices, to effectively identify what is bringing more value: to predict vs to monitor and for what usage… if not, the transfer will fail.

For example, the Leosphere-Onera licence: After ONERA granted a licence to the Leosphere start-up for its anemometric type of LIDAR, it become obvious that it is easier to sell the apparatus for measuring the wind potential than to sell the apparatus measuring in real-time the wind with the aim to CONTROL the WINDMILL itself. Finally it took 2 years to sell Lidars for wind prospection and 7 years to convince a major windmill manufacturer to monitor in real-time.

Path for innovation ***number 3 - Connect with other sectors*** needing the knowledge of the atmosphere or the use of similar sensors developed to monitor the atmosphere to monitor their specific environment (monitoring fluid flows, chemical composition, and particles density and size…).
In a brief analysis, the paths number 1 and 2 are more related on a value chain issue and the strategic decision must belong to the Commercialisation/TT Office of the same laboratory in "shortcutting" or not the "data consuming" scientist/colleagues by providing the market with measuring devices in spite of accurate predictions, along with the business case analysis to see which of the paths brings the most value.

Path number 3 is mostly linked to the cross fertilisation and support knowledge mechanisms occurring while performing the so called Open Innovation.



As we can see from the figure above, introducing the Open Innovation perforated funnel of professor Chesbrough, path number 3 involves mechanisms pictured in the low-level of the figure such as the

External Technology Insourcing when a technology developed by a EUFAR member will be adopted by an industrial from another sector or the Internal/External Venture Handling when a technology developed by a EUFAR member with the purpose of Meteorology or Manufacturer/Operator of Aircraft applications will be externalised in other sectors with reduced time to market and reinjected into the original funnel (have a look again at the Leosphere example below).

Leosphere adopted the anemometric Lidars developed by ONERA for the sake of wing vortex measurements to create a Lidar designed for wind prospection for the windmill farms. After succeeding in selling this product on this wind mill prospection market, Leosphere develop a new Lidar measuring accurately the shearing wind on airports runaway, thus coming back into originally aerospace innovation funnel. All this developments happened in les then 7 years inducing at least 3 years win on the aerospace's "airports niched market" average time to market >10 years.

4. How to proceed to the technology/ competency transfer

4.1-The first action to be taken and performed aiming to successfully transfer technology/ knowledge from EUFAR scientists to the market is to ***Train the Scientist*** in order to compensate/ overcome the cultural asymmetry (see the first generic guide for technology transfer). We definitely need to explain to scientists the interest for tech. transfer, show them who are the actors involved and mainly explain to them their mission not only to create knowledge but also to transfer this newly created knowledge in case of opportunities for value creation on the market. Additionally we need to clearly explain to them that if they want to reach the market they will need to adopt an entrepreneurially state of mind and behaviour but this can only be achieved on a voluntary basis on their part. Scientists only have to work with technicians (from the industrial partner) in order to disclose and communicate to them their knowledge on how to build and use the respective sensor for example…

Nota Bene: We can affirm, with no doubt from now, that the only way to get scientists involved on this task was via the commonly organised workshops between the expert group leaders and the TTO from ONERA with the aim to describe what Tech Transfer means, to what purpose it serves and why is important… and… it worked (!) producing in less than 6 months a Technology Profile Booklet that had not been produced under a full year and a half of various other initiatives.

4.2-Actions specific to the Path to innovate **number 1 – Use of data**… We (as a representative community) will need to work with the authorities to clearly identify which data must serve for the common wealth and then dispose them with open data access to everybody!
Then, we need to compare this to the existing norms to ensure compliance and clearly identify the costs to sustain these data type provisions. This cost must be sustainably assured from public money.
We also need to identify the way to use this type of information in case of crisis management (see the volcanic ash example) together with the authorities, based on their requirements, but also by meeting and discussing with operational forces for intervention (traffic regulators, fire and rescue departments, MoDs…)

All other obtained data must be "sold" to various actors needing them (including non-EUFAR scientists/colleagues searching for predictive models, unless if the European Commission will also consider these data as Common Wealth for our society – a clarifying discussion must be carried out on this topic as soon as possible). The different ways of providing these data to the market could so far include; payable libraries, providing data on request (impose compliance conditions for deliverables), interest in success fees to the applications contracted with market actors by the "data consuming" scientist…
These types of services must be decided generally within the respective laboratory producing the data but also producing predictive models due to the implications on the value extracted in return from the market (sales of real-time monitoring devices vs sales of predictions… one category of the scientists will get a contract while the other will not, measuring vs modellers). The local Commercialisation/TT Office would normally be able to deal with such a decision linked to this issue and this guide cannot provide generic practices because this is very specific to the local (Institute's) economic environments, however specific help could be provided on request by the Tech Transfer task leader of the EUFAR community (currently ONERA).

4.3-Actions specific to the Path to innovate **number 2** – ***Connect directly with the operating actors***
The local Tech Transfer and Sales Officers have to define commercial strategies to be discussed and validated with their existing clients (e.g. to propose them predictive tools to tailor the shape of their aircraft vs propose them real-time monitoring on board sensors plus command integrated software)…

This is also internal policy for each laboratory but the competition will be worldwide and cross sectoral, thus each local research Commercialisation and TT Office should address such a strategic issue and why not (?) share it at the EUFAR community level. The production of the common ***Industrial Partners Directory*** will be a first step to achieve such a collaboration. Certainly, this issue will be established and solved through the common governance rules to be adopted under the ongoing discussions to set up an AISBL (Belgian Law Association) for the EUFAR community. Playing the network will increase the chances, through establishing benchmarks, to set up the right value proposition to an existing client.

4.4- Actions specific to the Path to innovate **number 3 – Cross sectoral applications for Sensors**

This is the most challenging way to transfer technology from EUFAR community but also it could be the fastest to succeed. There are clear stages to be carried out and hereby we provide a non-exhaustive list of them:

- define the key words characterising the developed technology by trying to widen these key words (involvement of scientists with support from local TT Officers),
- try to enlarge the key words from properties to generic enlarged topics (Scientists + local Sales and Marketing Officers' contributions),
- use these sets of keywords on all the data basis available locally in order to discover who is publishing (including patents) on these topics and properties (Scientists + TT Officers and Documentarists/ Archivers)
- identify from these publications who are the actors and sectors involved in these topics and extract from this the respective domains (Documentarists + Marketing Officers) *(e.g. of Tel Aviv University's Tech Profiles which range from soil contamination devices to sectors like agricultural survey, civil engineering, electro-optical companies, asphalt and concrete monitoring… by simply using an adapted search on the espacenet patent database)*
- identify the traditional way of doing linked to these cross domains (Scientists by analysing the publications)
- get the competitive advantage of the couple tech X market thus discovered (all involved). As a result of this stage the respective EUFAR member will be able to **produce the Technology Profile** related to the respective developed technology, to be promoted to the industry through respective EUFAR actions addressing the Tech Transfer Task,
- confirm this advantage through accurate benchmarks with the traditional way of doing vs the EUFAR developed technology. This will be done within dedicated **collaborative workshops** with respective domains' industrial partners, TT Officers and scientists from both sides (industrial partners & EUFAR)
- once the competitive advantage of the EUFAR technology has demonstrated an analysis with the method DRL (Demand Readiness Level) vs TRL (Technology Readiness Level) must be performed in order to assess the possibility of closing a deal related to the transfer of the respective technology to the interested industrial player. Often a reasonable progress on the DRL (even by paying a marketing office, with contributions from the Scientist and the local TT Officers) must be achieved in order to facilitate such an agreement (see the "generic" guide for technology transfer already delivered to the EUFAR community and the need for a DRL+TRL >9),
- to better approach, negotiate and close the licence agreement, it is suitable to identify as far as possible the related business case based on the eventually newly adopted technology, developed by the EUFAR member, by the industrial partner. This will generate all the appropriate and pertinent arguments to be highlighted during the discussions which will follow to settle the licence agreement (local TT Officers),

- the remaining stage is the one related to the commercial approach (contact, proposition, pricing, negotiation of the IP rights…) plus closing the deal and proceeding to the technical work related to the effective transfer of knowledge (this work must be included in the pricing strategy). We could say that the settling of the licence agreement is just the “beginning” of the technology transfer but this is mainly related to technical collaboration between technical executives, and our scientists know how to handle very well such kind of work! One hint we could share with them is the need to find an internal “sponsor” within the industry partner to promote the project of absorbing the technology and definitely do everything possible to avoid the occurrence of the “Not Invented Here” syndrome. The only way that works well, from the ONERA’s experience, is to permanently bring the industrial scientists on a co-constructed project. Specific training could be needed related to this issue for the scientists from both sides, and this could be agreed while settling the agreement between the parties by their respective negotiators.

On all these stages and actions, the Technology Transfer Task leader for the EUFAR community (currently ONERA) could provide adapted support and help to achieve the related objectives.
Last but not least, do not forget to communicate in case of success stories. This definitely helps to change the mind-set and showcase that it is possible to create economic shared value based on our scientists’ findings.

5. Conclusion

Although the specificity of the EUFAR scientists, namely, 1) far from the market with a time to market of 10 years+ for any new developed technology, 2) far from the market by being interfaced by other types of scientists while trying to connect directly with market actors, we have demonstrated that innovation paths are existing and provide some actions to be carried out in order to succeed in this challenge. Potential success stories are already identified.

Ongoing activities have already proved that the mind-set of scientists could be modelled and trained to such a technology transfer challenge. Thus we successfully produced a first draft of the Technology Profiles Booklet to be promoted by EUFAR members to the industrial community and the disclosing of this technology offer has already created a good impact and generated good feedback from the community.

Further previewed activities will follow the described paths, within this guide, to innovate, and considering the already observed reactions gathering more scientists to join these kinds of activities, we do believe the EUFAR Scientists community will become an example on how to transfer advanced technology into various markets.

6. Annex: General guide on technology transfer issues for R&D partnership

Version 1, submitted by ONERA on 31 July 2015

ABSTRACT

The technology transfer process between a public laboratory and a company has been the subject of many publications and has been widely discussed in economic theory. This paper highlights several practices and fundamentals of such a process dealing specifically with emerging technologies occurred from the aerospace and defense R&D sectors.
The corpus of the paper draws partly upon the economic analyses of 'asymmetries' & 'dynamic and interactive capabilities' (and competencies), and for the rest upon empirical sources, being based on the recent experience of one of the most dynamic Technology Transfer Offices (TTOs) in France: the case of ONERA (the National Office for Aerospace Studies and Research) and its dyadic relations with the SMEs.
In such a cooperative, interactive innovation process, we will argue that certain collaborative tools or practices emerge, aimed at reducing information asymmetries or acting as compensation mechanisms for other types of asymmetries between the partners at a microeconomic level; especially in France where there is a gap between the public R&D laboratories and the SMEs in terms of Technology Readiness Levels (TRLs). Some of these compensation mechanisms, particularly those related to the knowledge economy, could be adapted and reshaped for agents engaged in R&D and innovation in various other sectors, perhaps inducing positive amplification effects on innovation behavior, and thereby on economic growth at the macroeconomic level within the "national and European innovation ecosystem".

Keywords: SMEs, technology transfer, information asymmetries, dynamic capabilities, innovation systems

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INTRODUCTION

The technology transfer process between a public laboratory and a company has been the subject of many publications and has been widely discussed in economic theory as well as in applied economics (e.g. in the *Journal of Technology Transfer*). Here we will deal with the specificities related to this process in the field of technology transfer arising from the field of aerospace and defense.
These specificities relate to the characteristics, capabilities and competencies ('capacities') of SMEs and public research laboratories. This paper will be based mainly on feedback regarding the strategy implemented for the development of an economically 'healthy' relationship between ONERA (*Office National d'Etudes et Recherches Aérospatiales*, the National Office for Aerospace Studies and Research) and the SMEs surrounding it with mostly dyadic relations between themselves. The choice and definition of collaborative tools will be explained together with the analysis of the initial results and the prospects envisaged.

We will contend that, in a cooperative process of innovation, these tools become mechanisms for reducing informational asymmetries **(**Stiglitz & Weiss, 1992**)** or "compensation mechanisms" (Paun, 2009) for other asymmetries between the various players at a microeconomic level. These newly identified asymmetries, **Institutional asymmetry** (regarding the institutionalist theory of Veblen, 1914), **Technological asymmetry** and **Risk asymmetry**, often act as barriers to the technology transfer process, while simultaneously being critical for the eventual high intensity of the innovations pursued. The greater the asymmetries, the stronger will be the impact on the intensity of innovations, always assuming that the differently involved actors in the innovation process do succeed in working together. This involves the effective implementation of asymmetries reduction (compensation mechanisms), through 'blending' the capacities for change of the various agents.

Some of these mechanisms, more related to the knowledge economy, could be adapted and reshaped for other agents in the R&D and innovation domain, and for evaluation or regulation authorities of this domain. Their implementation for these other players could induce an amplification effect on innovation and its direct effects on economic growth at the macroeconomic level within the framework of the "national innovation system" **(**Freeman, 1987; Lundvall, 1992; Nelson, 1993**)**.

FUNDAMENTALS AND ISSUES

In appealing to a systems approach, and accounting for the points of conjuncture and disjuncture between small companies and large establishments, and between research labs and aerospace/ defense companies/contractors, we consider both the vertical elements – here the progression from micro-level (of individual agents, like people and organisations) via the meso-level (of individual sectors and/or regions) up to the macro-level (of national systems) and even global levels – and of the horizontal dimension, in which the various types of asymmetry incurred by the various types of organisations with which we are concerned, viewed both individually and collectively.

Meaning of 'capabilities'

The line of argument we shall pursue is given by the recent popularity of the so-called 'dynamic capabilities' school, as launched by David Teece and his colleagues in the 1990s (Teece et al., 1997, etc.). Both words however fall into a category described by the eminent Austrian economist from the middle of the 20th century, Fritz Machlup (1959), as 'weasel-words', i.e. words that promised the hope of clarification but ended up just sowing more confusion, through their very presumptuousness; or more simply, words that mean less than they first appear to say. Mindful of such problems, Teece et al. thus define dynamic capabilities in terms of 3 P's, namely *position* and *paths*, which define the dynamics, together with 'processes', which we can interpret as '*business processes*', i.e. what we will term the 'functions of the firm', and this brings them close to our own final definition as provided below. These authors do not distinguish between capabilities and 'competencies' in their descriptions of the meanings, which is precisely where our own study takes off from.

Our approach, in brief, is to assess what 'capabilities' are through adapting Nobel Laureate Amartya Sen's concept of 'consumer capabilities',[1] according to which capabilities comprise the *ability* to consume the product effectively, together with the *circumstances* constraining that consumption process (e.g. the financial and legal environment in our case, or the 'entitlements' to income in Sen's situation of famines). 'Ability' to consume involves both the *competencies* acquired by purchasing[2] skills from other sources (as the ones related to the public R&D) and *capabilities* proper, learnt within the organisation. 'Capabilities' in this sense represent an intermediate transformational concept between orthodox 'characteristics' of a product, or technology, etc. (see Gorman, 1956; Lancaster, 1966) and the orthodox set of 'rewards' (or motivations) for making use of the characteristics for some stated purpose (e.g. utility in Sen's case of consumer capabilities). 'Capabilities' are highly heterogeneous as between individuals or organisations, in terms of both their differentiated nature, and the amounts with which each individual or organisation is endowed (or dynamically able to enhance them through learning).

Table 1 clarifies the distinction drawn in our analysis between capabilities and 'competencies', pointing out the need for both in order for a region or country (or individual firm or industry) to be able to claim its capacity with regard to full dynamic capabilities.[3]

Table 1: Competencies vs. Capabilities: Essential differences

Essential:	**Competencies**	**Capabilities**
1. Function	Enhancements to 'resources'	Enhancements to 'services'
2. Stocks	Human and R&D capital stocks	Knowledge stocks
3. Chain position	Inputs related	Outputs related
4. Product area	Specific, focused	General, adaptable
5. Supply–demand	Supply driven	Demand and supply driven
6. Stage	Potential	Realised
7. Development	Acquired and/or hired	Accumulated within
8. Learning	Learning by searching (STI)	Learning by doing (DUI)
9. Dynamics	Externally available as needed	Internally deployable in real time

The sum of competencies and capabilities then gives us a figure for 'capacity', as in building capacity both external and internal resources need to be meshed together. Such a meshing or 'blending' process is contrary to the difficult alternatives of blocking or bridging proposed by Putnam et al. (1993). We shall return to this point in discussing interactivity below.

[1] Defined for very different purposes by Sen (e.g. for famines in poor countries; see Sen, 1985, etc.).
[2] Even if there are no monetary charges for this acquisition process, there must be opportunity costs of the time etc. involved, as in Friedman's celebrated concept of there being "no such thing as a free lunch" – without even attempting to cost up the risks involved in changing one's skill base (see below).
[3] The list here is loosely based on that given by von Tunzelmann (2009) which also lists a further 8 'associated' differences, regarded as less definitive and more by way of elaboration. Key pointers to the definitional differences are probably points (1) – functional differences, and (7) to (9) – the dynamics.

This three-tiered and nested approach is then extended by our research (e.g. von Tunzelmann & Wang, 2003, 2007; von Tunzelmann, 2009, etc.) to producer capabilities (involving production of all kinds and not necessarily standard manufacturing processes), drawing for this purpose on Edith Penrose's theory of the 'growth of the firm' (Penrose, 1959) and also to 'supplier capabilities', where issues of IPRs may become paramount because of possibilities for appropriation by giant firms. Nevertheless the IPRs granted by the public laboratories within the TechTransfer process will create the criticalness needed by the industrial partner on its value distribution chain and thus creating IP rights by a good IP strategy is very important while performing the public R&D activities.

Thus in Figure 1, there are 3 types of actors, which occupy the full area of prospective agents. From a supply chain or supply network perspective, all actions are ones of production or consumption or supply, and often all three at the same time. Thus in the *process of producing* this paper, intended for the *consumption* of various types of readers including policy-makers as well as academics, there is therefore a 'forward linkage' to users, in addition to 'backward linkage' (in the sense of Hirschman, 1958) to our *suppliers* – on this occasion the accumulated wisdom of our forebears, plus the accumulation of technology in the form of instruments and artefacts, like computer hardware and software.

This 3x3 matrix thus applies quite generally to any form of production, whether governmental (producing policies, etc.), or academics (producing research papers), or firms (producing products), however different the actual production processes are and also the conditions of governance. Most of these are in fact multi-agencies, whereby academics produce students and consultancy reports as well as 'papers'; governments produce physical and social infrastructure as well as policies; increasingly one finds manufacturing companies producing services alongside their traditional goods, etc. (Davies & Hobday, 2005). Note that we find it useful to distinguish between ***agents***, as the physical embodiments of people or the organisations to which they belong, with either being represented by its name, and ***actors***, representing the multiple roles that nearly all agents will have to play.
Not surprisingly, perhaps, we have to relax this distinction in our discussion to follow, where we shall be taking ONERA or the entire EUFAR Community as 'the' technology supplier and the SMEs or other type of industrials as 'the' customers appropriating new technologies and thus creating dynamic capabilities granting potential for socio-economic impact.

Figure 1: The model of capabilities in the technology supply chain

Actors:	Suppliers (technology)	Producers	Consumers
Characteristics	S&T possibilities	Production possibilities	Product possibilities
Capabilities	Technological capabilities	Producer capabilities	Consumer capabilities
Rewards	IPR returns	Profitability	Utility

supply

demand

Knowledge exchange

In the figure, the markets operate effectively, though they are limited to being the outcome of exercising capabilities and competencies. In the row of characteristics, there is first the matching of the supply of and demand for technology (NB a 'derived demand',[4] depending on the next market along, which is the one given here in the final column as the match between the supply of and demand for products).

There are mirror image mappings to those from the capability vector to that of characteristics, in the mappings from capabilities to motivations, or 'rewards', again inserting a physical differentiation into a value-defined space (here 'profitability' rather than prices though). Finally there are non-market exchanges which take place directly among the agent producers themselves, with the horizontal arrows typically representing asymmetries of knowledge between the agents and the respective capabilities.

Dynamic and interactive capabilities

The first 'static' version of the approach as discussed so far via Figure 1 can then be straightforwardly extended further to the context of interactive learning (Lundvall, 1992), and hence to 'dynamic capabilities' proper (Teece et al., 1997). As shown in the diagram, the interactive elements are partly mediated through market mechanisms relating to supply and demand factors, in connection with both the characteristics (product possibilities, etc.) and the rewards (profitability etc.); however the most interesting form of interactive learning consists of direct interchanges of knowledge among the actors, shown by the two-headed horizontal arrows in Figure 1.

Although this is often represented as 'absorptive capacity', we take here the opportunity for a more proactive role, of 'giving as good as one is getting' through reciprocity in networks and partnerships. This might be termed the third face of R&D,[5] following the first face of original technological development and the second face of the ability to reproduce the technological results of others – this third face indicates what the company or other recipient agent can bring to the negotiating table in terms of the stage of knowledge acquisition.

In these respects there is already a dynamic component to interactive capabilities, but strictly speaking dynamic capabilities in our sense of the term concern responses in real time to stimuli, such as would be emitted by market competition or technological change. 'Real time' here signifies a period of time which extends for just long enough to capture some or all of the potential rewards from the innovation to hand to match the new requirements, i.e. any suitable set of human and non-human resources, while the latter is more a question of adequate entrepreneurial flair. All of this accounts for our stress on speed and catching-up in real-time activities of the organisation.

Relationships posited can be thought of as linked dyads, with alternative time sequences (i.e. with the supplier-producer links and producer-consumer links preceding or succeeding each other in rather random fashion). The effectiveness of such links depends on the motivations (incentives of expected profitability etc.) but also the 'capabilities' for operating the links, on both sides of each dyadic relationship. We will give an example on how to use this notion of dynamic capabilities in the chapter related to tools to be implemented and used for an enhanced tech. transfer.

Context, positioning and role of the actors in technology based innovation

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[4] cf. von Tunzelmann, 1995, p. 2.

[5] The reference here is to the seminal paper by Cohen and Levinthal (1989), which discusses the first 'two faces'.

Specificities of the Aerospace and Defence field

Hence Figure 2 presents a classification of the market sectors according to two parameters: the time involved in launching products resulting from a new technology in the market, and the complexity of the products intended for this market, roughly approximated by the cost of a unit of the product **(**Stephan, 2006**)**.

Stephan, in presenting this figure, proposed a generic limit to innovation process control (up to the successful delivery of the new good and/or service to the market) by the carrier-creator of the technology itself. The originally defined curve, of the kind already noted in our survey in Part I above, supposes that a new product requiring very low development costs or complexity could be introduced to a market if time were expandable. We consider that for a low complexity product with low development costs many actors could proceed to develop this type of new product. The time for introduction into the market will depend mainly on its acceptability by consumers. As soon as they can accept the new product, everybody could provide it. Thus the time will be cut short instead of being expandable (or else the product will never be introduced because of never getting accepted).
The original defined curve supposes also that a new product requiring unlimited development costs with exceptionally high complexity could be introduced in a market only if it could be delivered in a very short time ('real-time'). The development means are assumed to be limited even in a large industrial group. This will induce a limit on engaging costs for any economic agent.

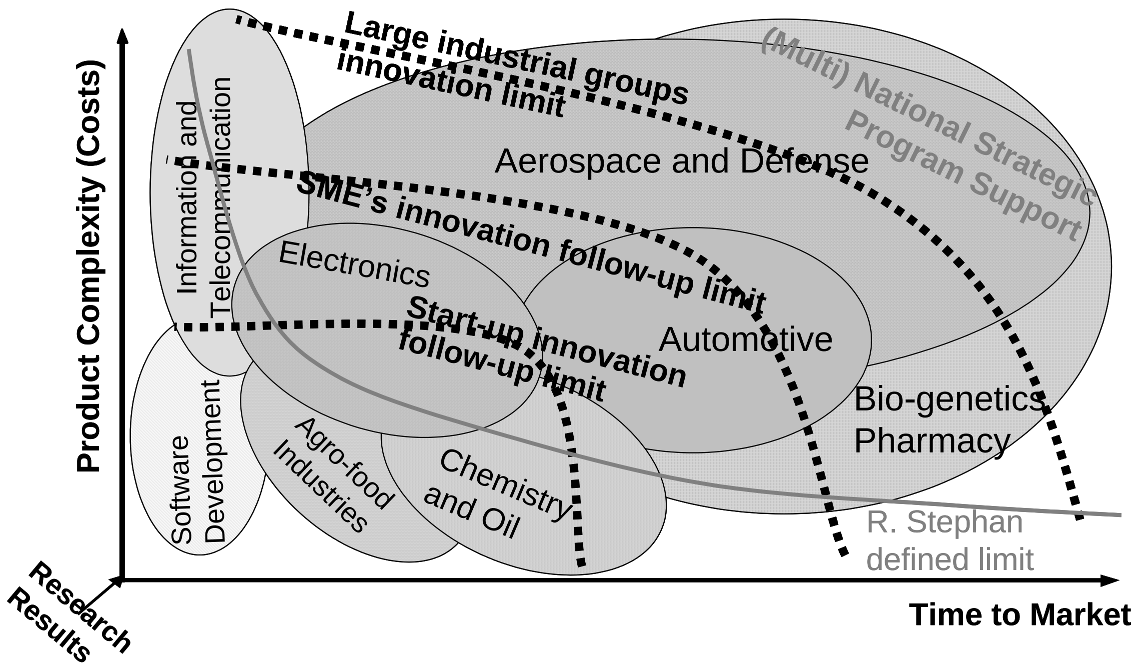

Figure 2: Limits to innovation process control by the creator (or assimilator) of technology, by technological sector: - R Stephan's limit - - Authors' proposed limits

Acknowledging this analysis with Stephan, we nevertheless contend that this generic limit curve has to be transformed in an elliptic type curve from an initial hyperbolic type, of the kind encountered previously in discussing time-cost trade-offs above. The basic reason for abandoning the hyperbolic shape is derived from considering the sectoral space here and thus the (approximate) sectoral contrasts.

It also must be admitted that an SME has less material means to establish a successful new good/service in the market than a large group. This is even more evident for a start-up partner. Thus we also propose to divide the limit curve into three branches corresponding to these three types of agents. These new proposed limits are generically represented in Figure 2.

The specificity of the aerospace and defence markets asserts itself very quickly because these sectors, which are generally ‘complex systems’ (Davies & Hobday, 2005), require a lot of time for the development and introduction of a new product to the market. We note that even large groups, beyond a certain limit, need institutional support at the national level, if not at the international level, to develop new technologies.

By being located within the upper limit of the diagram, the large aerospace sector and French and European defence groups stand out as designated partners for successfully ‘bearing’, i.e. acting as generator, carrier and user of (hence, all the ‘actor’ roles for) the new technologies suggested and/or developed by the public aerospace R&D. This is particularly the case for the incremental or specialized innovation of the large groups. Such ‘bearing’ is however less obvious in the case of technological breakthroughs (see McCooe, quoted in Golob, 2006), and this is even more the case in the civil aerospace sector where technologies used on-board planes must be safe and tested.

For these aspects, since its creation ONERA has developed and maintained effective strategic partnerships with the large national groups which have mostly become multinationals in recent years. This partnership policy will not be the subject of our analysis here. Therefore we will highlight within the next figure what could be the various gates allowing successful transfer of technologies to large industrial partners.

The fundamental question raised during the development of ONERA’s implementation strategy is that of access to markets, for breakthrough technologies resulting from a specialized research sector such as aerospace. From this point of view, the preceding diagram, presenting the limits to innovation processes, illustrates the point that, to put a ‘breakthrough technology’ on the market, thus challenging the existing products and/or business models, such as may be designed by a national skill centre, the best vectors are the SMEs. This provides the systemic element of the dynamic scale economies already referred to in Part I.

Technological demonstrations that result in innovation will not necessarily take place in the aerospace market but can arise in any of the market sectors in which the SME receiving the technology can itself control the innovation process completely (until the successful introduction of the new product to the market). Some niche markets will be accessible, even in the aerospace sector (green aviation, small-scale drones, leisure, etc.). Once the technology is demonstrated, there are strong chances that the large aerospace groups will integrate this technology as a tested module into the systems they are designing (Mouchnino & Sautel, 2007).

The strategic choice was taken at ONERA to develop also a partnership relationship with a national and European SME. If no SME is identified, the launching of a start-up partner could be studied, subject to the economic outlook and adequate financial support.

The next diagram is showcasing both, how the various players are positioned on to the TRL and who is deciding to develop and implement the emerging technology at the existing various gates within the internal existing or to be created Industrial programs.

In fact, the public R&D is positioned more on to the TRL1 to TRL 3-4 activities. Some applied R&D centres like the Carnot or Fraunhofer Institutes successfully develop technology reaching levels of TRL 6 but the public R&D are mainly operating in TRL1 & 2 barely going on the Proof of Concept, TRL3 level. These technologies could find a gate to entry within the technological development chain of a large Industrial only through their R&D direction on a consortium based agreement in collaborative research in TRL 2 or by direct contracts if at least the proof of concept was achieved always with the R&D direction as an internal supporter for this development. The major barrier to such a technology transfer will be the way of managing the Not Invented here syndrome that the exiting researchers within the industrial partner will eventually developed. At the TRL 3 level the key person to continue the development of the transferred technology will be the development (or for some industrials the "methods") office.

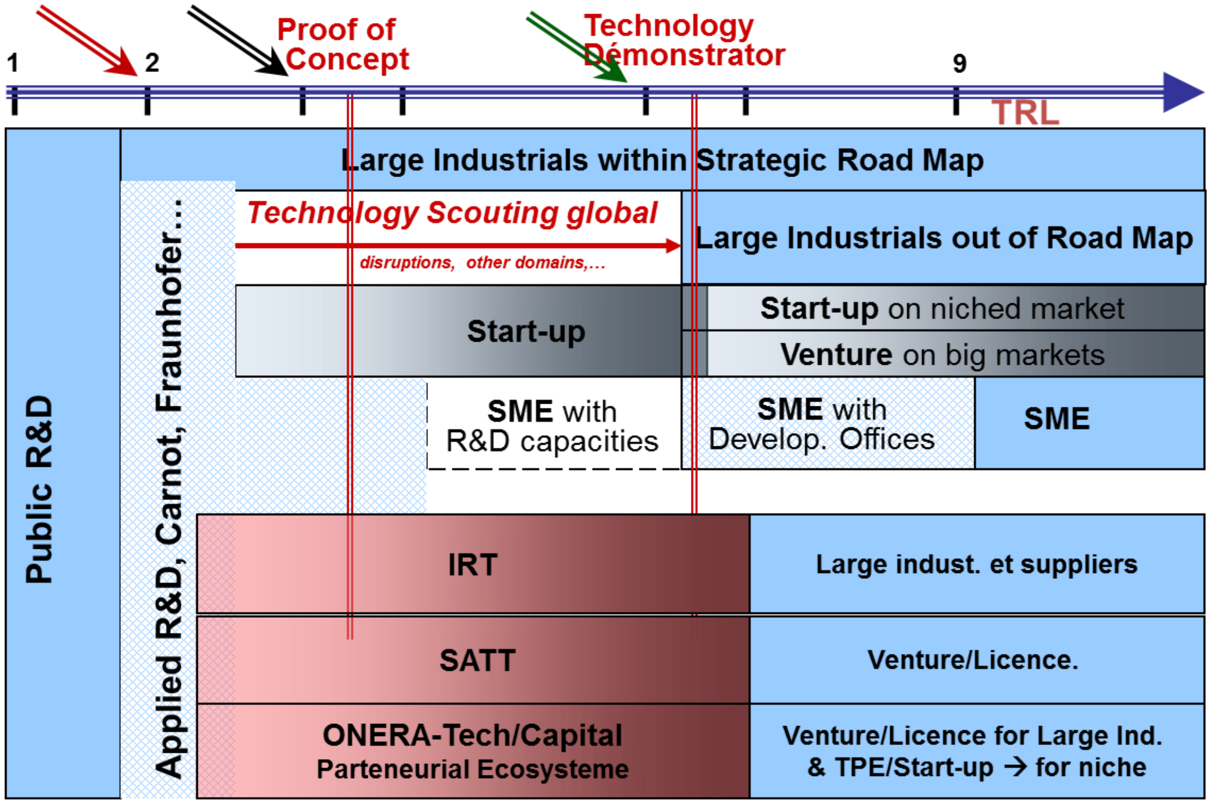

Figure 3 : Positioning of the various economic players on the TRL level scale and the 3 main entry gates within while dealing technology with a large industrial in red, black and green arrows

The large industrial partners are carrying out activities from TRL 2 to 9 within their strategic road maps and of course they are actors on their markets. They are also able to identify (for those possessing competitive technology scouting units) emerging technologies developed outside their company and apparently out of their strategic road maps. To inject such a technology into their programs only convicting the program Managers will provide successful technology transfer… but nevertheless the Supply Chain manager needs to acknowledge an existing reliable supplier!!!

On the diagram the start-up is positioned first between TRL 3 and the TRL 6. This is the generally acknowledge job of a start-up, to exit a disruptive technology from the laboratory and to perform successfully technology demonstration in operational conditions (TRL6). If the new product will tackle an existing market where big operators are dominating the market, they will propose a deal to the start-up or be integrating the start-up such a new business unit within their group or by proposing a venture. The start-up could develop by itself on eventual niche market with the help of specialized venture capital investors.

With the SMEs we appoint an eventual technological gap due to the lack of R&D capacities existing within such a small company. This gap was filled in France by the SATT (technology Transfer acceleration companies) in technology Push approach (implementing emerging technologies into the market) or through the IRT (Research and Technology Institutes) created by major industrials together with their risk sharing major suppliers in market pull approach declining their commonly agreed strategic road maps.

ONERA, nowadays, is creating his own accelerator, ONERA-Tech, which will be accompanied by an investment fund ONERA -Capital&Transfer, mainly dedicated to accelerate developments of technology transfer projects to SMEs partners within a market pull approach; although, this relationship with SMEs faces several major issues.

Public R&D laboratories-SME relationship

Like any healthy dyadic partnership, that between ONERA and an SME must be a winning one for both parties. Both partners must have strong positions **(**Cowan, Jonard & Zimmermann, 2003) with each adopting its own role so that their collaboration generates significant added value. So ONERA develops its best technological solutions, possibly breakthrough technologies, and the SME implements its product development, industrialization and marketing capabilities in order to reinforce its competitive advantage in its markets or to create new ones.

These complementary roles, based for one side on a ‘craftsman instinct’ and for the other on a ‘predatory instinct’, opposable in the sense given by the theory of Veblen **(**1899**),** generate significant asymmetries between the two partners.

Figure 4 recalls the existing asymmetries between the public R&D laboratories and the SMEs in France by showcasing their respecting positions with regard to the TRLs (Mankins, 1995);[6] it should be stressed for joint projects. It relies on simple and tested principles of « win - win » and « give - give », providing benefits for each participant, as summarised below:

[6] This figure was first presented and generally accepted at the ‘Rendez Vous Carnot’, Lyon, France, 2010, in the last Round Table dedicated to collaboration between Carnot Institutes and the SMEs.

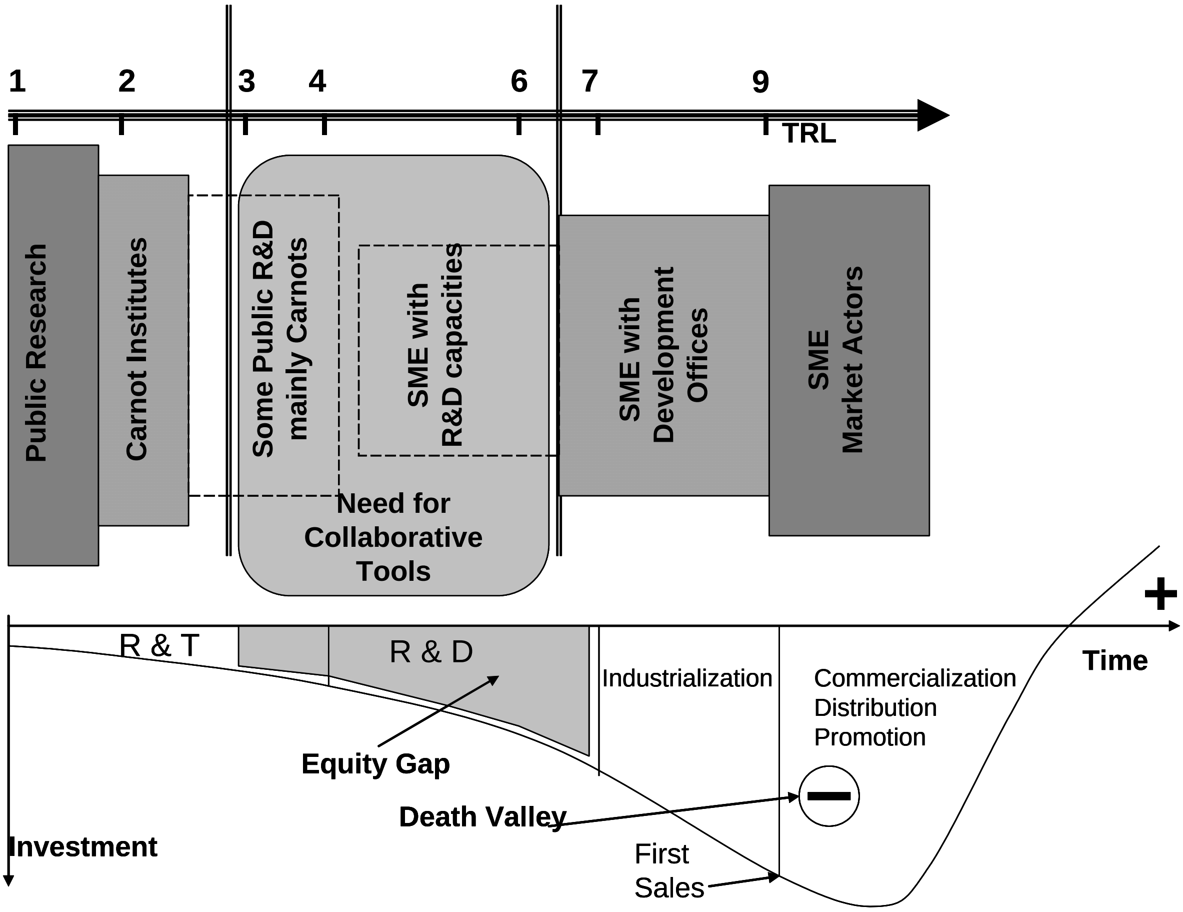

Figure 4: Asymmetries between public R&D laboratories and SMEs, by TRL score

It should be stressed that the majority of the public R&D laboratories in France carry out their activities at the levels TRL 1 (basic research) and TRL 2 (applied research). The 33 Carnot Institutes (facts from 2010), being responsible for 470 million of research carried on in partnership with industry, representing about a half of the yearly budget for French research undertaken in partnership with industry, are generally well involved in applied research (TRL 2). Very few of the Carnot Institutes could carry their research up to laboratory demonstration levels (TRL 3-4). Exceptionally and limited to particular programs, some of the Carnot Institutes could bring their technology to the operational levels (TRL 6-7).

Beside these figures, the SMEs are currently running their business at TRL 9 (these are selling products, services or components). Fewer than 10% of French SMEs have Development Offices able to integrate (or absorb) operational prototypes (TRL 6-7), in order to structure production chains and introduce new products to the market. And even fewer have R&D capacities able to understand technologies available at Lab Demonstration Levels (TRL 3-4). Thus, the Technological Asymmetry existing between public R&D labs and the SMEs becomes obvious.

In addition, is well known that between the same levels an equity gap is evident in some European countries, hence the European Investment Fund (EIF) and several public-owned banks (like CDC in France) have dedicated important financing programs to compensate for this Europe-specific ‘amorcage’ equity gap. This of itself will induce an important Risk Asymmetry between the public R&D and the SMEs.

These asymmetries must be reduced (for the informational asymmetries) or compensated for (technological capacities, financial and institutional risks) in order to support this new co-development relationship between the parties, as put forward in this analysis. The collaborative tools will thus be reduction and/or compensation mechanisms of the existing asymmetries between ONERA and its SME partners, with the aim of creating a "Trust environment" between the two agents. This affirmation could be extended to all the EUFAR members and applied to their relation with the SMEs.
Owing to their small size, but also to the structural weaknesses of the innovation support system set up by SMEs and/or start-up partners in France (Serfati, 2008; Levy & Jouyet, 2007), French SMEs, but we could easily admit that this is the case for European SMEs, must have suitable support mechanisms (private or public) for the success of a possible common development program with the public R&D laboratories, in order to absorb new technology and to make a success of their international commercial deployment.

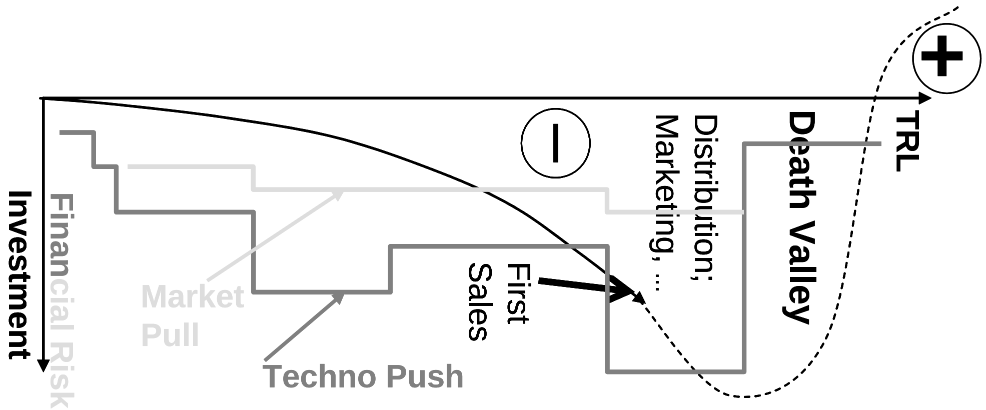

Figure 5: Risk curves related to the Technology Development Investment Curve

Two different approaches were targeted by ONERA's Technology Transfer Office (TTO). More than ¾ of the signed 60 agreements were obtained through a Market-Pull approach and under ¼ were obtained from a Technology-Push approach. Figure 5 supports this part of our analysis.

Indeed, following an intensive advertising campaign based on slogans like: "Come to see us if you have a Technology issue! We are the McGivers of the Science and you will never be alone", the majority of its SME partners did come to see ONERA addressing their technology issues. They had generally already identified a business-growing opportunity while calling on ONERA's TTO and they were looking for missing competencies in their company. We call this a Market-Pull approach. Technology-Push occurs when ONERA's TTO promotes a technology newly developed within ONERA and negotiates a license with an interested SME (or start-up).

Market-Pull projects have until now been successful to a higher degree. Accordingly, we propose our analysis of these results. In Figure 5, the risk curve for the technology-push approach is given by the grey line, while the dark grey line shows the case of the market-pull approach. We can observe that both exhibit a high level of risk while investing in operational technology demonstrations and above all in launching New Products (goods and services) into the market. Nevertheless, we remain confident about our implicit assertion in Figure 3 that, throughout the cycle, the risk levels are lower in the Market-Pull approach than with Technology-Push.

This lower risk exposure is induced at each stage by the fact that the SME partner has already identified a market and already possesses a structured production chain (including a supply chain).

These considerations act as drivers throughout the technology collaborative development process, raising the company's rating on the TRL scale, thus reducing its risks and costs. The Market-Pull approach also seems to accelerate the technology development process; thereby accentuating the dynamic capabilities that the firm is able to parade.

We further adopted a hybrid strategy for ONERA while working with SMEs. This method to hybridize, DRL vs TRL, will be described in the Tools dedicated Chapter. Indeed even if the market-pull approach seems to be less risky and sooner beneficial, and even if it is producing incremental and often radical innovations by changing the domain for the adopted aerospace technology, we do believe that some technology-push activity will continue to be important for eventually nurturing disruptive innovations in the laboratories core business domain. Another important reason in continuing to promote technology-push activities through its TTO is the higher degree of motivation provided to its scientists while promoting their newly developed technologies.

This hybrid strategy places the agents of the innovation system in a cooperative network generating newly created value through a process of technology transfer.

GUIDELINES for PARTNERSHIP INNOVATIVE STRATEGY

Introduction

We have seen in previous chapters that the only way to create socio-economic impact from the R&D results is through the highly collaborative process of technology transfer between R&D labs and industrial partners. Existing asymmetries between such different partners induce the implementation of collaborative tools aiming to compensate these asymmetries while providing to the industrial partners their newly acquired Dynamic capabilities, capabilities creating the necessary potential for the firms to conquer the markets with the newly created product/services based on the transferred technologies. In order to successfully create such a socio-economic impact some fundamentals need to be achieved.

Thus, in first stage a set of questions need their answers in order to **Build** a potentially **Successful Business Case** : **What** Product/Service, to **Whom** it will be sell on what **Market**, and **Why** it will be bought (**discriminant advantage** from technology performance, best **distribution channel** by the **most appropriate** technology adopting and **industrialisation partner**).

To achieve that there is a need to create the **Opportunity of Meeting Points** between R&D labs and Industrial Partners (driven by entrepreneurial approach). This could be done through events, promotion (media, internet, IP assets platforms, conferences), discover market workshops (see Fraunhoffer practices), partnerships with incubators, SME clusters, Masters in Entrepreneurship,…

As a reminder, Figure 3 showcases the eventual **Entry Gates** within various types of industrial actors. Important attention must be given to the good identification of such Entry gates and to the humans "**Gate Keepers**" and their respective motivations and drivers (R&D directors to promote a technology in TRL 2-3, Program Managers to promote a technology in TRL 6 etc.). The most important detail must be given to the **Deal Makers** as business developers, jurists, IP analysts and attorneys and the technology supporter within the technology adopting industrial partner. They need to team together to clear the path for the joint working teams effectively carrying out the technology transfer, unless they could adopt lock-in attitudes.

Therefore, assuming that everything is going as planned; another important issue will be how to **Make the Deal**. The issues to be addressed and the solutions to be negotiated will be the following:

- Identification of the IP rights to be transferred and their Owner: Patents, Secret Know-how, Software…
- IP rights granted for Use (identification of the need), Exploitation, Manufacturing
- Exclusivity: Yes/No, Limits…
- Domain: territories, market sectors,…
- Duration: associated or not to the Domain, and to development/commercial Objectives
- Objectives; related to exploitation, to utilization
- IP rights to be conserved: for internal needs, for R& D, manufacturing, use or exploitation
- Pricing and staging,
- Technology ready to plug or need of further works for maturation in view of transfer ; definition of a common program
- Miscellaneous: Responsibility, Insurances, Assistance, Confidentiality vs Publication, Cancelation Policy…

We will describe in further details some necessary tools to be implemented, although based on ONERA's practice, these tools could be adopted by all other EUFAR community members.
The ONERA-SME technology transfer process cannot be analysed without taking account of the relationships of the two players with their own reference frames, in terms of evaluation and sectoral/territorial regulations, in the sense of Granovetter (1985). These are mechanisms that are external to the simple ONERA-SME relationship which must intervene and accompany this dual relationship throughout the collaborative project, and some of the collaborative tools proposed take these mechanisms into account.

Development and description of collaborative tools

Initially, an analysis of the role of each player during the innovation process is proposed and even, albeit in a more restrictive way, in the technology transfer phase. As mentioned above, the activity of the public R&D laboratories in France involves, structurally, TRL levels lower than level 3-4, corresponding to the laboratory prototype stage. Only a few basic ideas conceived by the researchers attain this level of technological maturity and even fewer cross levels 3-4 to go on to levels 6-7, corresponding to the demonstrator in operational conditions or a product. This is because the development of technological demonstrators is no longer part of the mission given to public research in France, a situation that is actually even worse for products.

If, generically, during the TRL 1 level (basic research) and TRL 2 level (applied research), 1000 original ideas finish up numbering 100 (via the personal filter of each researcher leading him or her to retain only one idea for every ten that he or she may have), are then cut down from 100 to 10 (by discussions with his or her 'close' circle of colleagues), and finally slimmed down from 10 to 2 or 3 by debates with the line management and/or decision committees, it will be interesting to see how these 2 or 3 results from various projects can cross level TRL 2 to arrive at levels 3-4 of prototyping.

Asymmetries in technology transfer relations and respective collaborative tools to compensate them

It can be seen that the research activities in TRL 1 and 2 are really mostly by the research laboratories because few SMEs are able to conduct their own research at these low TRL levels. Most innovating

SMEs (apart from those that ate really small labs in their own right) invest more in R&D activities after demonstrating technological feasibility, because their ultimate mission is to sell products successfully, with an economic logic of seeking profits.

So, what can be done with a technology that reaches a research laboratory at level TRL 2? At this stage, a laboratory prototype can be shown to be feasible by simulation and/or the existence of certain elementary components with strong chances of success. Who must now invest in the development of this prototype and on which criteria should the decision is based?

It seems obvious that at this stage the laboratory should consult the possible bearing vectors in the market: large groups and SMEs. If the technology developed corresponds to a strategic axis of development in a large group, quite naturally the latter will be interested in the appropriation of this technology or, at least, in a competitiveness comparison with other solutions. The partnership process that would take place between the laboratory and this large group is not the subject of this analysis.

The case that interests us is that in which an existing SME is interested in this technology, whatever its branch of industry. When no SME or large group expresses interest in the use of the new technology then there only remains the option of launching a start-up partner, in the case of a 'disruptive' technology with high development risks and market potential, to be confirmed by market research; otherwise the development has to be abandoned.

Technological and risk asymmetry

On the two assumptions, both for a SME and for a start-up partner, the problem of maturing technology up to the TRL 3-4 level is still the same. It will be very difficult to get the SME or the start-up partner to finance this maturation. All this is related to the structural problem of financing developments in France but also to the lack of leading-edge scientific skills within the SME, allowing dialog with researchers and the appropriation of technology under the TRL 3-4. An asymmetry of technological capacity is revealed here and an asymmetry of the risk (financial) between the two participants: the public research laboratory and the small company.

Indeed, 95% of French SMEs are small companies with less than 50 employees (INSEE, date). The development and demonstration of a new technology based on emerging technology from aerospace together research cost at least around one million euros (according to our own experience in the relationships with our SME partners), without counting the launching and development costs of the product line. However, most of the innovation assistance available in France is limited to 50% of the global amount (see Oseo, date, on refundable advance). This means that an SME that undertakes the development of a new product for a breakthrough innovation must assume half of the costs itself. For an SME with twenty people, €500K may well represent 25% of its annual wage bill.

Here, a significant risk asymmetry is to be noted between the SME and ONERA because possible failure could mean a cessation of activities for the former. The same amount represents the cost of four ONERA researchers. Moreover, the financial risk exists and is not negligible, especially in the EPIC culture, where we will see later that the scientists involved in the technology transfer relationship are very little aware of the risk for ONERA compared to the degree of the risk assumed by the SME. Other authors (e.g. Serfati, 2008) have also stressed the importance of social relationships (including cultural relationships) in the innovation process. This difference in mentality was identified without any ambiguity in the collaborations undertaken by ONERA with various SMEs.

The shared risk development contract of ONERA serves as example.

A mechanism to try to solve this technological maturation and asymmetry problem has been developed at ONERA: the shared risk development contract. This type of contract was developed and signed, for the first time in France, between an EPIC and a business firm.

For this phase of technology maturation ranging between TRL 2 and TRLs 3-4, the risk is still too great to be borne entirely by an SME as long as the technological proof, at least in the laboratory, as well as a complete comprehension of the technology, have not been achieved. It seemed right to us that ONERA, as a creator of technology, should be able to join future industrial and commercial owners in order to reduce the risks, and share the possible future benefits. The partnership is based on a technical and economic analysis of various phases of the development and on a Business Plan detailing the market prospects and investment returns on the new product. Based on this, ONERA can decide to assume part or all of the costs, within the framework of the co-development, the refunding of which, with profit-sharing based on business success, will take place or not, depending on the prospects for the use of the product.

The negotiation of the percentage allocated to sales, so as to cover ONERA's costs and its exposure to risk, is conducted according to criteria allowing the development of the company but also bearing in mind the fact that ONERA must make a positive return on all the operations of this kind. Thus, this contract is not a sort of license, or a subsidy. The principles on which this contract is based are those of a service provided by ONERA on the basis of a determinable (though undetermined) price with payments deferred in time, negotiated between the parties on the basis of later sales and for a length of time agreed upon as part of the same negotiation.

This type of contract proves to be a very good tool, both financially but also technically, for collaboration with co-design in mind, for the development of a new product, a logic equivalent to that described by Cowan (2003). This tool means two parties can together cross, within the meaning of Aoki's theory (Aoki, 2000), based on a Nash equilibrium (Nash, 1950), a possible financial and technological comprehension barrier that may otherwise induce blocking.

In addition to compensating for risk and technological asymmetries between the two parties, this contract has also subsequently proved to be a good tool for reducing transactional information asymmetries (Akerlof, 1970; Stiglitz & Weiss, 1992) between the start-up partner and its investors. Indeed, at the time of the phase of 'due diligence' between the creators of the start-up partners and the Business Angels, the shared risk development contract, signed with ONERA, yields paramount information on both the product and the target market, and on the technological developments and their costs.

Institutional asymmetry (mentality and behaviour)

The shared risk development contract is a collaborative tool that compensates for technological and risk asymmetries. Such a tool also compensates indirectly for a very important asymmetry in the relation between the transmitter and the receiver in the process of technology transfer, institutional asymmetry, a term introduced here analogously with the terminology of institutional economy, within the meaning of "thought and action practices" by Veblen (1899) of "shared mental models" and "belief structures that intervene as formal and abstract constraints to structure human interactions" by North (1994).

This asymmetry has been thoroughly analysed because it can sometimes induce a more significant form of blocking in a dual relationship: cultural blocking. The institutional word must be understood as a sum of the rules, but also in its abstract aspect, as a sum of beliefs, prejudices, instincts and behaviours: “Institutions are dominant thought and action practices” (Veblen, 1899). All these elements are generated historically, according to the way in which the actions are carried out and are assessed, but more especially through received education.

Historically, applied research in France is really quite concentrated in national research centers specialized in a particular field (IFP, CEA, ONERA, Inrets, Inra, Inria, etc.). The universities have generally not been perceived as possible players in applied R&D. The proof is that before the Allegre Law in 1999, very few universities in France had a research result utilization service, and even these, before the Pecresse Law in 2007, did not have a complete autonomy which would allow them, among other things, to have a close relationship with the economic world.

The Summary report of assessment of the universities of the wave B (AERES) made an observation which alludes to this: “... Socio-economic milieus.... their influence on the policies and strategies of the establishments are generally weak, because of their lower level of involvement in the councils of the establishments”.

The utilisation activity developed since the Allegre law seems itself to be directed toward research contractualisation and expertise-based services, but hardly at all in the field of technology transfer. The following can be read in the same report: “Utilization - this is a declared objective in all establishment strategies. Management structures (service, SAIC, subsidiary companies, direction, etc.) exist in the majority of these, for industrial contracts and service performance. On the other hand, the management of patents and licenses and, generally, of intellectual property, financially costly and requiring specialized skills, is accessible to these establishments with great difficulty. A really effective utilization policy would require the creation of consortia within a regional or even national framework to reach the critical size necessary for effectiveness.”

Leaving, in passing, to the reader the appreciation of the desirable ways of improvement, as they are recommended in this quotation, we should mention that, nowhere in this report is a mechanism suggested for listening to the needs for development being expressed by the markets.

In the **Guide of the expert** - Wave C of May 2008 of the same Agency (AERES) we can find positive developments going in the direction, in terms of the evaluation criteria, of taking into account activities around the utilisation of research within the organisations being assessed.

It is explicitly requested that the number of patents, the number of declarations of inventions, the cost of the patents, as well as the revenue generated by these all be taken into account but, above all, the number of licenses. However, other fundamental indicators are lacking for a complete measurement of utilization activity, such as the revenue from possible capital shares held in the companies profiting from technology transfer, the evolution of the value of these companies, or the number of jobs created on the basis of these technologies.

This, coupled with consideration of a criterion on the patentable technology detection activity within the establishment, but not of one on the capacity of listening to the market needs, or the capacity to carry out market research, will generate a culture of technology push instead of a market driven culture, generally recognized as a better generator of innovation.

Thus, the **economic culture** of the researchers is built throughout their career by indicators on the basis of which they are assessed, the most important indicator being recognition by peers, gained mainly through publications by the researcher according to panel reviews. However, while publication circulates research results efficiently, without an adequate preliminary control it is contrary to the utilization mission of national industry and likely to reveal unprotected know-how.

In this same guide, the number of A and A+ type publishers is an important criterion in assessing establishments. The identification criteria of these authors include international patent deposits but do not stress those that were granted a license. Also, protection of the results is confused with their utilisation and as a result it is likely that a great number of patents of no importance may be obtained because they do not contain any criterion bearing on their economic impact. It would undoubtedly be necessary to optimize the respective weights of a license, the incomes obtained with the latter, the patent and the publication.

There is a legitimate question to be asked here: when does a license generating significant income have the same weight (or even a greater weight) than an article published in Nature? There is indeed no antagonism between a patent and the publication of results from their source, only a priority on the submitting of the patent is to be respected. Our colleagues in the Anglo-Saxon world have shown that publications in Nature are not in contradiction with very profitable licenses. If a license counted for three traditional patents or nine publications … could this induce a change of mentality within the public research community?

Moreover, this mentality is the subject of an unambiguous analysis in this same report concerning the governorship of research establishments: "in multiple-field establishments, faculty-centred organisation remains very vigorous. In certain recent universities, it is an acknowledged will. The evolution of mentalities and practices is thus very slow…"

The recent **"Carnot Label"** awarded to research establishments with partner research activities with industry (Carnot Law), has made it possible to evaluate the co-operation between industry and public research in France. Thus, the 33 Carnot Institutes, accounting for only 12% of the French public R&D manpower, generate nearly 50% of the research contracts with industry, for a total budget of €450 M, representing merely 1/3 of their annual consolidated budget. The share of this budget with the SME is however insignificant.

So how a researcher could be convinced that the utilisation of research results is a noble aspect of his or her activity? This mentality, based rather on the "craftsman instinct" within the meaning of Veblen (1914), induces a strong asymmetry in the relationship between a researcher and an SME director, who will rather act according to a "predator instinct" from the "cultural" point of view, during their interaction for a technology transfer. This asymmetry may be strong at the beginning of the relationship, and can be compensated for gradually if a favourable environment is created to help the relationship to evolve from a transactional framework towards that of co-operation.

Now that this institutional asymmetry concept has been introduced, we can see that the technological capacity asymmetry triggers collaboration between both participants and that the compensation of information and institutional asymmetries is the facilitator because, at the beginning of their relationship, both parties face problems arising at the same time from the lack of technical information but also from the capacity to implement these once they are available (for example, it is not enough to read a patent to be able to manufacture a new product).

The Spin-off Charters serve as examples of mechanisms to manage the asymmetries.

The shared risk development contract is one of the mechanisms allowing the compensation of institutional, technological and financial risk asymmetries, during the first phases of technology transfer. To allow later developments, up to the marketing of products, ONERA has adapted its **Spin-off Charter**, as another collaboration tool, in order to support the integration of researchers into the SME, when a technology transfer towards the SME takes place.

This evolution results from acknowledging the failure of the existing spin-off policies of the public research establishments, whether in France or elsewhere in Europe. The great scarcity of researcher spin-offs is a logical consequence of the natural differences in skills necessary as between the enterprise world and that of research. Success in the creation of a company depends not only on the quality of technology, but particularly on that of the management team, and on financial and operational resources, in order to control marketing, commercial, financial, industrial and productive components, making it possible to move, in a limited period of time, from a good technology to a business success. The goal of the Charter revision, toward integration of the researcher wishing to "spin-off" into an existing structure, is thus to support the meeting, within a pre-existent framework, that of the SMEs, of these components of success so as to reduce the risks, both for the researcher, and the SME, and ONERA as well.

The departure of the researcher to the SME wishing to accommodate him or her, with the transfer of a technology in which he or she is an expert, takes place under conditions that are at the same time safe and incentivising; in particular, the traditional conditions: the possibility of returning to ONERA during the first three years, financial aid, and the financing of training to reinforce the necessary skills for his or her new mission.

The main point is however the condition of opening the SME capital to the researcher in order to position him or her as an "entrepreneur" on the same level as his or her new partners (at least 5% for a small company; flexible for an average-sized company). This makes development of "cultural" positioning possible for the spin-off researcher, and a clear confirmation of the interest of the receiving SME for the new business that the researcher will contribute to develop and manage within it.

ONERA-SME Technology Charter

In order to give a more general framework to these relations, to gather the collaborative tools, to define the principles of the expected collaboration with the SME, and to ensure this collaboration policy can be maintained for the foreseeable future, ONERA made the strategic choice of setting up an ONERA-SME partner technology Charter.

This Charter itself had to go beyond the simple problems of technology transfer and explore all the collaboration possibilities between ONERA and the small business world. It represents a moral engagement of the two parties, based on the principles and methods of collaboration and the values governing them. It also means the two parties wishing to collaborate can be on active watch, reciprocally validating their collaboration potential, and be able to start a collaborative project at the earliest opportunity.

This Charter is fully positioned as an institutional collaborative tool, within the meaning of Aoki's theory (Aoki, 2000). The two participants do more than give themselves the means by which to develop together because they are both on active technological watch in their respective markets, identifying opportunities for joint projects.

It relies on simple and tested principles of « win - win » and « give - give », providing benefits for each participant, as summarised below:

i) <u>Mutual benefits</u>

a) Technological[7] benefits and opportunities for an SME
Such partnerships make it possible for the SME to have access to R&D contracts in partnership with ONERA, to scientific expertise across the entire civil and defence aerospace field, and to technology by means of licenses, simulations, calculations, testing tools, simulation tools or software runs[8] and technological watches.

These can reinforce its competitive advantages from accumulating competencies out of the framework of R&D contracts, by proposing solutions that involve a stronger scientific added value thanks to the contribution of ONERA, both from becoming integrated into experimental projects and technological demonstrations, and by allowing more competitive services with a better adjusted division of the types of services provided by ONERA and the SME.

They permit giving access to markets and customers that would be difficult for an SME to reach alone, since the latter will now have the benefit of the "ONERA Partner" label to present to large institutional and industrial accounts, thereby dodging some of the weaknesses of being small through taking part in the cooperation project.

The SME can also profit from the outcome of developments in contracts with ONERA for progressing towards commercial use of new products in its markets.

b) Benefits and opportunities for ONERA
This partnership reinforces the competitive advantages of ONERA within the framework of R&D contracts, achieving this in various ways:

- by offering more cost-competitive services with a superior division of the types of service jointly provided by ONERA and the SME;
- by proposing more flexible and more directly operational solutions;
- by allowing greater reactivity, in particular in "original" and "changing" requests, within the framework of prototypes and experimental projects;
- by better controlling the costs and times of the production tasks necessary for the projects.

The partnership offers access to customers/end-users not directly accessible by ONERA, supports mutual enrichment and emulation between the teams of ONERA and the SME, allows ONERA to be proactive and play a driving role in the industrial world, and offers more dynamic potential outlets for utilising the research results, particularly for ONERA's technology transfers.

[7] For SMEs that involve themselves in the development of technologies in addition to their use.
[8] Launching the computations on ONERA's super-computers

ii) Types of partnership

Several partnership modes can be implemented to carry out this project, such as partnerships in R&D contracts, the expertise and use of ONERA methods, shared risk development contracts, technology transfer/utilisation of ONERA know-how; this goes as far as the detachment of researchers and/or their spin-off into the SME.

iii) Profile of targeted SMEs

The desirable profile for **targeted SMEs** must allow fast self-identification by the SME of its own capacity to enter into a partnership framework with ONERA by:

- having a production activity or technology service;
- working in a field that can benefit from the outcome of ONERA's research;
- devoting – or having an objective to devote – at least 8% of its AC to R&D (this minimum can be modulated according to the size of the company)
- having financial viability;
- satisfying the SME criteria of the European Union;
- adhering to the values of the *ONERA-SME Charter*.

iv) The "values"

This *Charter* is primarily a moral engagement between the parties, resting in particular on a common vision of the business rules of the partnership:

- *innovation based on scientific and technical excellence*: scientific and technical excellence is one of the basic elements identified by the SME for the development of its innovating products and services. This excellence is based on an internal R&D policy at the SME, as well as on external contributions, including among others those of ONERA;
- *a quest for performance*: the concretization and perpetuation of success are guaranteed by a permanent search by the SME for improved economic performance, within the framework of the development and marketing of its goods and services;
- *constructive competition and fair-play*: in the event of competition between SMEs on contractual or utilization activities, this will only proceed on the basis of technical and economic criteria, seeking performance and in a spirit of fair-play between them, respecting the customer and/or ONERA. In particular, it would be a case of forbidding higher technical or economic bids likely to lead to an unidentified risk for the customer and/or ONERA. In the event of competition with ONERA, the rules of free competition apply; a reciprocal tendering procedure could be considered to assess a possible cooperative venture;
- *independence*: each SME preserves its independence; the network may be mobilized in defence of shared interests, but – barring exceptions – cannot be used to support private interests;
- *commercial ethics*: the operation of the project shall be according to recognized commercial rules of ethics, in particular to exclude any private interest situation between ONERA and SME researchers that may generate specific conflicts.

DRL vs TRL method

The main activities of the Technology Transfer Offices are related to Technology Push approaches. An important number of these offices either integrate or collaborate closely with business incubators ready to support start-up activities. The main discussions and interests of both Technology Transfer executives and economists trying to conceptualise the innovation practices (e.g. AUTM or T2S Annual Meeting) are also related to how to commercialise R&D results for the benefit of industrial partners. Detecting, promoting, identifying prospects and licensing are considered business as usual by all the TT officers.

Indeed, all these considerations are focused on some central questions: how do I fit what my R&D colleagues developed into the market? How to find the appropriate market injection vector? Is it an industrial group, an SME or do I need to support my R&D colleagues in their attempting to create a successful start-up?

Current issues

All of these, induce a generally acknowledgment inside TTO community that excepting the “lucky blockbusters” or some of the “big names” the Technology Transfer Offices are not financially beneficial. Important discussions were carried out between TT executives informally at the AUTM and T2S last meetings related to the Industrial Groups roaring on Universities “expensive” IP rights and their newly engaged R&D activities with emerging countries Universities.

Professor Chris Hill from George Mason University gave a memorable talk, related to this question, at the 2010 T2S Annual Meeting, with the occasion of his Keynote Lecture. He gave a significant and unanimous acknowledge pledge on the importance to introduce the Technology Transfer activities inside the Core Activities expected from an University and thus accepting the fact that this activity has not necessary to be beneficial while inducing economic value in the region.

Following his lecture, Florin Paun publicly suggested, based on his experience at ONERA and further to his economic research works on innovation actors’ asymmetries and “hybridisation tendency of the innovation system”, that as one of the Core Expectations from an University is to induce economic value in the region, not only the Technology Transfer activity must be recognized like one of the Core Activities of the University (as he just suggested) but also it must be reshaped from a Technology Push priority to an appropriate “equilibrium between Technology Push and Market Pull through a hybridised approach”:
“We need to change our jobs from “Look how nice is my technology baby” to “I’m here to listen to you, to co-conceive solutions and to support you with my knowledge in your technology development project”. TTO actually tend to identify the need to take more into consideration the technology needs of the regional SMEs without replacing their complementary technology push activities”

Note: This intervention was also publicly acknowledged and encouraged for publication by the community. The DRL vs TRL method was conceived further to this acknowledgement and is based on a 5-year relationship between 2006 and 2010, with more than 80 SME partners, on the drivers and barriers perceived inside this relationship and on more than 40 interviews with scientists and industrial representatives involved in direct collaborations linked to technology or knowledge transfer.

ONERA’s Technology Transfer Experience

Starting with 2005, ONERA adopted a voluntary strategy towards SMEs. It was based on the assumption made that the SMEs are the most adapted vectors for technology demonstration out of the aerospace domain. The experience proved that the straight Technology Push approach was not the most appropriate to put our newly developed technologies on different other market domains. ONERA needed to adapt our relationship on a win-win basis.

ONERA starts to promote not its newly developed technologies but its competencies. It conceived, promoted and signed in 2007 with more than 40 SME, at that time, an ONERA-SME collaboration Charter. This Charter, signed by more than 100 partners nowadays, is based on well-defined and agreed role between the parties. The SME cluster around ONERA became "eyes and ears" on the Market for the perceived technological needs while ONERA became knowledge provider to the SMEs for their innovative development projects.

Previously to this new orientation, ONERA signed about one technology transfer agreement each 2 years in technology push. We signed about 10 per year during last years, 8 induced by Market Pull approach and 2 by Technology Push. This multiplication effect on the Technology Push deal flow was rather unexpected. But, with the experience ONERA got and by **institutionalising** its approach (with internal and external recognition), this positive demultiplication effect turned to recognise that the better comprehension and understanding between ONERA scientists and the industrial representatives was partial obtained also trough their previously carried Market Pull innovation projects.

The fundamental generally observed fact on each of the technology transfer agreement signed was that none of the obtained deals could be classified in a pure Technology Push or Market Pull approach. Indeed, all the agreements were obtained around a particularly given moment when a Technology Push approach meat an existing Market Pull approach made in parallel by the industrial partner.

We have hardly tried to identify and well define the conditions making feasible a license agreement deal; conditions aimed to predict the particularly given moment for the junction of the two types of approaches.

We thus tried to understand and arrange these conditions by relating them to specific processes perception while referring at the TRLs scale. Something was missing and it didn't work. We could not identify generally valid conditions or definitions and we accepted this particularity of adapted solutions "any time is case by case" different from the standardized approach.

Introduction of a new concept for understanding and measuring the Market Pull approach:

We observed that the innovation process was subordinated to the reference adopted system. Indeed, all the actors involved in Technology Transfer process have their attention "glued" to the TRL scale. In practice, even speaking about the Customer Voice we still ask (or are asked) about "what is the TRL level" for the appropriate technology sensed to tackle the Expressed Need by an industrial who's addressing our R&D Commercialization Office.

Why continuing to refuse the evidence? : Even the Customer Voice is sunk inside the TRL scale and our minds are thus Technology Push driven. Why not referring from now on, when facing an industrial expressing to the R&D Commercialization Office to a new scale related this time to what we call the **Demand Readiness Level (DLR)** (Paun, F. , 2011) identified by a customer on a given market?

It actually means that it is the right timing to define an additional scale and plot it in a reverse manner related to the classic TRL scale in order to have the appropriate comprehension of the Market pull process. The author is proposing this schematic further for a better comprehension.

DMEN Level	Demand Readiness Level		
1	Occurrence of a Feeling "something is missing"		
2	Identification of a specific need	Market certification and sales authorization	9
3	Identification of the expected functionalities for the new Product/Service	Product Industrialization	8
4	Quantification of the expected functionalities	Industrial Prototype	7
5	Identification of the systemic capabilities (including the project leadership)	Field demonstration for the whole system	6
6	Translation of the expected functionalities into needed capabilities to build the response	Technology development	5
7	Definition of the necessary and sufficient competencies and resources	Laboratory demonstration	4
8	Identification of the Experts possessing the competencies	Research to prove feasibility	3
9	Building the adapted answer to the expressed need on the market	Applied research	2
		Fundamental research	1
		Description Technology Readiness Level	**TRL Level**

Paun. F., 2010 : Demand Readiness Level as equilibrium tool for the hybridization between Technology Push et Market Pull approaches

For example, if an industrial partner has a DRL on 8, he/she will be able to identify and speak with the appropriate scientist to launch a collaborative R&D program for developing a new product or service. Same type of matching between different levels could be observed at each level of the previous table.

This is now better understood why "each case is a specific one". Looking in two references systems, one for the Technology Push approach and the other one for the Market Pull approach, we could predict the given particularly timing when an technology transfer agreement is ready for signature. Further research are on the process to Postulate that the Technology Transfer Agreements between R&D laboratories and Industrials are only possible if the sum DLR+TRL is at least equal to 10.

The common technological maturing laboratory as a collaboration tool

In addition to other collaborative tools, it seems appropriate, in the case of complex projects requiring a technological maturation between TRL 2 and TRLs 3-4, for it to be possible for this to take place in the public laboratory's own maturation lab, a joint arrangement for which future technological developments are managed cooperatively with the SME partners. This laboratory would accommodate mixed teams composed of SME (or start-up) employees and researchers. The personnel costs would have to be borne by each party for its own staff. Mechanisms external to the SME-ONERA relationship, making it possible to ensure up to 80% of the wages of a professor (or researcher) recruited by an SME, have been put in place recently at Oséo.

The question of the financing of this Common Technological Maturation laboratory could also be resolved by making use of the additional Carnot contributions (under the Carnot Law) that the Institutes that are members of the Carnot Institute Association receive, to boost their scientific and technological resources within the framework of their partnership policy. This is because one of the goals of the Carnot label, amongst others, is to support technology transfers. It remains a fact that no technological maturation should be undertaken without preliminary market research, with product/market cross-referencing as obligatory.

The Common Technological Maturation laboratory would also function as a new collaborative tool, facilitating the compensation and reduction of technological asymmetries (in its institutional aspect and in terms of the lack of information) between the two participants in the technology transfer but also as compensation for the risk asymmetry.

RESULTS

To date, 100 SMEs have signed the *ONERA-SME Charter* and more than 50 licensing agreements, know-how communication agreements or shared risk development contracts are currently running, with various industrial partners in a variety of fields. Of these, 38 were signed over the last years, corresponding to the new development policy implement then, while the remaining (12) represent the historical "heritage" of the old ONERA development policy.

Table 2: ONERA–linked SME partners (selection only)

Partner	Application	Type of collaboration
Leosphere	Wind lidar	License, common R&D and spin-off contract
Oktal-SE	Electromagnetic environment simulation	Software licenses and common R&D contracts.
Phasics	Laser interferometer	License and ONERA post-graduate student recruiting
Protip	Biomedical prosthesis containing porous Titanium	License and shared risk development contract
Ixsea	Inertial navigation	License
Sirehna	Drones and gliders	Common R&D contract and software license in fluids
Satimo	Medical imagery	Common development contract and license
Isitek	Medical supervision in residence	License on sensors
Microcertec	US machining of ceramics	License
Fogale-nanotech	Capacitive sensors	License
Andheo	Fluid mechanics and energetic	Software license and common R&D contracts
Sofratest	Flow measuring	License
C3EM	Fissure monitor and experimental data acquisition station in wind tunnels	License, common R&D contracts
Secapem	Real-time shot acquisition and validation system	R & D contract and software license considered
Mapaero	Pressure-sensitive paint	Know-how communication agreement
Michalex	Micro-indentation at very high temperatures	License and shared risk development contract
ACV Aeroservice	Quiet green aircraft	R & D contract and shared risk development contract envisaged

Nheolis	New type of wind power station	Shared risk development contract
Keopsys	Laser	License

Following the successful implementation of the new collaborative tools during this period, the number of collaboration agreements signed went from one to more than ten agreements per year. The number of spin-offs went from one spin-off every five years to one spin-off on average per year. Fifteen new proposals for common R&D contracts also came to light during this last period.
Table 2 provides a selection of the partnerships with SMEs, this selection having been made on the basis of their diversity.

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