LES NOTES DE L'IRIS

POOLING OF DEFENCE RESEARCH AND DEVELOPMENT

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SUMMARY

The Challenges of Pooling Defence R&D

The pooling and sharing of capabilities is first and foremost a response to reductions in defence budgets. With countries unable to afford to buy the military equipment they need on their own, they have no choice but to cooperate. Pooling of defence R&D should be viewed in this context. It also has the political objective of encouraging industrial consolidation in armaments at the European level and thereby creating a European defence technological and industrial base (DTIB) to serve the common security and defence policy (CSDP), although the Member States all take a different view of this approach.

In Europe, nearly €8.6 billion is allocated to R&D, of which 75% is earmarked for the most advanced technological developments, corresponding to technical readiness levels (TRL) 8 and 9[1]. Research and Technology (R&T), encompassing more upstream research, before the development stage, represents just under €2 billion[2].

With respect to R&T and R&D (TRLs 1 to 6, and even 7), in 2007 the EU Member States agreed to a collaborative R&T spending target of 20%[3]. This target is far from being achieved as the percentage of pooled R&T within the EU is 11.8%, even though, as discussed below, pooling is easier to implement for low TRLs.

There are several types of research and technology pooling :

- Pooling in the form of shared results: the cooperating partners each finance the full cost of the research and share all the results. This was the case with the Franco-German cooperation of the 1960s and 1970s. There was little communication between the research teams and they viewed each other as competitors even though the results would ultimately be shared. This cooperation/pooling was costly, as the research teams were duplicated, but it guaranteed success in terms of technological innovation. For budgetary and business competition reasons, this type of pooling no longer exists today ;

- Pooling with shared resources and results. In this case, the objective is to create critical financial mass so that research can be conducted with no duplication in the use of funds. The States and companies pool their technological and financial capabilities with the aim of jointly developing a technology. The results of the research benefit all the cooperating countries ;

- Pooling with a division of labour and of the technologies to be developed. In this case, interdependence is created between the companies. Pooling can succeed if the allocation of the property rights and results is such that the interdependence concerns

[1] A nine-level scale is used in research to measure technological developments based on their maturity. TRLs 8 and 9, the highest levels, correspond to the highest degree of maturity. The lowest TRLs range from level 1 (“Basic principles observed and reported”) to level 7 (“System prototype demonstration in an operational environment”).

[2] These amounts are nevertheless low compared with US R&D spending, which is close to €58 billion.

[3] June 2007 ministerial meeting of the European Defence Agency steering board.

companies that are developing complementary expertise[4]. In the case of shared technologies, the interdependence is such that joint ventures are the most appropriate economic and industrial model, rather than cooperation.

Companies may be interested in pooling their R&D effort for economic reasons or to promote innovation, which is itself positive for their development. However, not all conditions are favourable for pooling, as the literature suggests.

Lessons from the Literature on R&D Pooling

Little has been written about the pooling of defence R&D. However, over the last 20 years, a number of academic works and scientific articles have been published on R&D pooling in general.

It is widely agreed that research, because it allows a company to innovate, is a competitiveness issue. At a time when companies are competing globally, research can therefore be a decisive strategic factor. However, its costs are as high as the results are unpredictable.

Pooling can thus enable a company to fund its research while sharing the risks. Interfere cooperation has even become a requirement for companies that want to compete at the global level[5]. It also enables companies to accumulate knowledge, benefit from the expertise of their networks of complementary partners, and gain access to emerging skills[6]. By joining a network of companies and of knowledge, a company can ensure it is not left out of the flow and exchange of information, which are often at least as important as innovation itself and which enable the company to expand its know-how to new applications[7].

As early as 1962, Arrow's work demonstrated that innovation activities produce technological externalities[8]. It is not just the initial investor who benefits from an investment in R&D and the ensuing innovation. Because an innovation creates a stimulating and constructive atmosphere and because it is fully or partially transferable, it opens up new opportunities (spill-over or technology transfer) to other players. This situation encourages companies to seek to pool their R&D because they themselves cannot make use of all the results related to their initial investment. The benefit to the partner will, however, depend on its absorptive capacity, or the extent of the opportunities it can expect from the pooling.

Lastly, with respect to the basic research in which companies are more reluctant to invest, given the associated risks, cooperation creates

[4] This is the situation for the nEUROn demonstrator programme led by Dassault, which includes five other European companies across five different countries.

[5] Desreumaux A. (1994), « Problèmes organisationnels de la coopération inter-firmes » (« organisational problems in inter-firm cooperation »), *Cahier de recherche du CLAREE*, n°94/5

[6] Miotti L., Sachwald F. (2003),"Co-operative R&D: Why and with whom? An integrated framework of analysis", *Research Policy*, spring 2003.

[7] Hagedoorn J. (2002), "Inter-firm R&D partnerships: an overview of major trends and patterns since 1960", *Research Policy*, vol.31, pp. 477-492.

[8] Arrow (1962), "The economic implications of learning by doing", *Review of Economic Studies*, Vol. 29.

a network that enables them to remain current on a subject and, where applicable, gain access to other players, such as private or academic laboratory researchers, and to these players' equipment. Cooperation can therefore work like an incubator which, because it exists, will ultimately lead to an innovation that was not necessarily expected initially.

Against this backdrop, companies find pooling more attractive for upstream research, or even basic research. Companies are reluctant to invest in this type of research, which is considered more risky and less profitable (at least in the short term), and are therefore more motivated to share costs and risks. Furthermore, the commercial applications are not derived directly from this research and each company can design different products based on the results of this cooperation[9].

The methods of pooling are also important. Critical issues include the funding of pooled projects, the allocation of the work or property rights, management of the teams and technology transfers. While investments may seem less profitable during the upstream R&D phase, at least in the medium term, the closer the research moves to the development phase, the more complicated the cooperation becomes, even if it began long ago. Thus, when joint ventures have been created to coordinate pooling, they are often dissolved when the development stage has been reached.

The pooling of defence R&D is discussed in two articles. The first, by Jordan and Williams[10], concerns the cooperation on the JSF/F-35 combat aircraft programme. They list three issues that may arise when European and US companies pool defence R&D:

- The legal framework for technology transfers. US ITAR legislation on export controls is a significant constraint that does not provide non-US companies with any incentive to pool their R&D with US companies as they run the risk of not being able to freely use the products of this joint research, particularly in the case of exports;
- Questions relating to the scale of production. US companies have much more potential for economies of scale than their competitors, which gives them a competitive edge over European companies. US companies therefore have little incentive to cooperate, unless it helps them increase their market share or their economies of scale. For European companies, the issue of pooling is more one of access to the most advanced technologies, which is therefore not in the interest of US companies;
- The question of property rights is therefore critical: why would US companies pay more to own a right they already own?

The requirements of interoperability, particularly on the battlefield, can be an incentive to cooperate, but the concerns of

[9]Yami S., Nicquevert B., Nordberg M. (2006), "Le consortium de recherche comme stratégie collective aglomérée : le cas de la « collaboration ATLAS » au CERN" ("the research consortium as agglomerated collective strategy: the example of the "ATLAS collaboration" at CERN"), in *Finance, contrôle et stratégie*, Vol. 9, n°3, pp.191-217.

[10]Jordan G., Williams T. (2009), "Defence Research and Development in the Atlantic Nations, A RUSI European Security Programme Study", Occasional Paper.

those on the ground are not those of the companies or of the agencies of the State responsible for the control of sensitive technologies. In this context, US companies have little motivation to pool R&D, even though operational requirements may compel the armed forces to do so.

Choo and Bontis[11] suggest that R&D produces innovations in specific areas (security and defence) that are a matter of national sovereignty and have a strategic dimension. From this standpoint, the commercial use of this research is more complex than for any other innovation; the best possible outcome is a dual-use innovation. Moreover, these cooperations lead to short production runs, thus limiting the potential for economies of scale. It might be assumed that the same applies to R&D, with the benefit of pooling lying more in the capacity to innovate than in the outlook for savings.

Lastly, in the case of defence R&D, it is not just two players that have a stake in the benefits of pooling: the States — in addition to companies — are concerned because they have, until now, funded the majority of defence R&D and because defence is a matter of national sovereignty. Against this backdrop, the obstacles to pooling are at once more varied and more substantial in defence than in the civilian sector, even though the rules are the same. The question of intellectual property is, for example, more complex: who will own this property? Who will have the right to use it? Does it make sense to patent the results of the research, given that they are quite often protected by secrecy classifications?

Pooling of Defence R&D in Europe: What Rules Apply ?

The Financial Stakes

Defence R&T and R&D spending in Europe is concentrated in a few States. France and the United Kingdom are in the first group. These two countries alone account for approximately 65-70% of R&T spending in Europe, with each earmarking more than €500 million for defence research. Next comes Germany which, at €400 million, allocates about half the amount France allocates to defence R&T. Italy is ahead of Sweden, Poland and the Netherlands, with likely just over €200 million[12]. These three countries allocate less than €100 million to defence R&T.

The significant differences in defence R&T funding levels are also an obstacle to pooling, as it is easier for countries to cooperate when their expertise in defence technologies is the same, meaning the research effort is similar.

An examination of national defence research and technology models also shows significant variations. Generally speaking, it is the defence ministries that fund defence R&T, with the exception of Poland and Italy, where other ministries are involved. In particular, the entities that receive the funds and that conduct

[11] Choo C. W., Bontis N. (2002*), The Strategic Management of Intellectual Capital and Organizational Knowledge*, Oxford University Press p.17

[12] It is nevertheless difficult to determine Italy's R&T spending, as some of this amount is financed by the Ministry of Industry. The EDA's figures therefore underestimate these expenditures.

the research are not identical in nature. Thus, in France, with the exception of ONERA (the French Aerospace Lab) for certain aeronautics research and CEA (the French Alternative Energies and Atomic Energy Commission) in nuclear, it is primarily the defence companies that conduct the research (in conjunction with university laboratories for more basic research). In the United Kingdom, Germany, the Netherlands and Sweden, it is the public agencies or foundations that conduct defence research. These different structures also impede the pooling of defence research, with the results of the research being transformed more quickly into commercial products in France.

Defence research can be pooled bilaterally or multilaterally. At the bilateral level, the experience gained from Franco-British framework is highly instructive. At the multilateral level, pooling occurs mainly within the European Defence Agency.

Bilateral Cooperation : The Franco-British Example

At the bilateral level, the Franco-British cooperation, with a target of €50 million pledged to the cooperation per year and per country, represents one-fifth to one-third of France's pooling of defence R&T, depending on the year. This observation leads to the first rule of defence pooling: **it is easier to pool defence research with a country that makes a similar financial effort and is at the same technological level**. This interpretation was confirmed to us by representatives of different countries and manufacturers and applies in particular as from the mid-TRLs. As a German armaments engineer said, "as the heterogeneity of the participants' technological levels inevitably increases as their number rises, the most advanced countries will be even less inclined to open their files, given that they will expect less valuable information in return."[13] It is easier to cooperate on basic research with low TRLs because it is often undertaken in university laboratories. Additionally, the extreme heterogeneity of the financial effort with respect to defence R&T within EU countries explains why there are a limited number of partners cooperating in this area.

Yet the obstacles the two countries are known to face in pooling defence research suggest other rules necessary to understanding the factors in play in defence research pooling.

First, the French entrust defence research to their companies as from mid-level TRLs while the British rely on the Defence Science and Technology Laboratory (DSTL), which is a public body. The DSTL may then seek out private companies to bring the research to maturity. This poses problems in terms of the allocation of property rights, with the issue of British companies having access to the results of the research programme when they have not been party to the programme itself. It therefore took six months to reach an agreement on the allocation rules for the Innovation and Technology Partnership (ITP) for missiles. The differences between the structures responsible

[13] *Strategemata, ou des ruses employées contre l'armement germain* (Strategemata, or the ruses used against German armaments), Sextus Julius Frontinus Juvenis, éditions Octopus, 2012

for overseeing defence R&T are therefore a constraint.

Of the ten research areas identified in the Lancaster House Treaty of 2 November 2010, two are moving forward more quickly than the others: cooperation on missiles and on Future Combat Air Systems (FCAS). The explanations are threefold:

- Pooling/cooperation is promoted when a joint venture exists or when a capability sector has already been consolidated. This is the case for missiles with the MBDA company and the Complex Weapons team in the United Kingdom;
- Cooperation if promoted when the capability ambitions objectives are the same. This is the case for combat aircraft with FCAS;
- Lastly, cooperation is promoted when there is political support at the very highest levels. This is the case, again, for combat aircraft and missiles.

The Franco-British cooperation also confirms one of the rules identified in the literature on civil R&D: it is easier to pool defence R&T at low or mid-levels than at high levels, in other words, before there are any commercial stakes. This also explains why it has been easier to cooperate on combat aircraft, as the cooperation is currently taking place at low or mid-TRLs.

Dassault attempted to solve the problem of pooling at higher TRLs, without forming a joint venture, with its nEUROn UCAV demonstrator project[14]. This model of pooling creates a division of labour among different companies. From a technological and economic standpoint, the model has been a success, but the question remains whether it can be reproduced on an industrial scale.

This also implies that the states are willing to accept a cooperation plan in which the labour is divided on a case-by-case, programme-by-programme basis, with the cooperating companies selected according to the technological expertise required.

Multilateral cooperation : an intergovernmental or Community network?

The European Defence Agency

Multilateral cooperation in defence takes place primarily within the European Defence Agency (EDA). France's policy has until now been to consider that any cooperation among more than two cooperating partners should take place within the Agency.

Several lessons can be drawn from the cooperation within the EDA. Cooperation among the 26[15] is an exception for several reasons:

- The greater the number of cooperating countries, the more difficult it becomes to manage the cooperation: the difficulty of

[14] The programme comprises France, Italy, Sweden, Spain, Greece and Switzerland.
[15] As Denmark is not part of the CSDP, it is not a member of the European Defence Agency.

defining common interests, including industrial interests, increases with the number of cooperating partners;

- It is difficult for countries that do not have the same financial involvement and the same technological level to cooperate. The concern of the largest countries, as well as that of their companies, is the dissemination of technologies in keeping with the rule that everyone has access to the results of a study conducted jointly. It is therefore difficult, if not impossible, for 26 countries to cooperate. This explains why Category A projects, which are open to the 26 members of the EDA, are less successful than Category B projects, which are closed projects limited to a few States and which are managed by the Agency's cooperating States.

The Agency has sought to remedy this problem with Category A framework programmes. These are in the form of modular projects, such as the unmanned maritime systems project, called the Joint Investment Programme (JIP) and which brings together all the countries that would like to be involved. Within this framework programme, the States cooperate on technological building blocks in a more restricted format with Category B projects. The Agency thus hopes to engage all the States in research programmes while maintaining the operational rules governing cooperation on technological building blocks that satisfy the countries that are the most heavily involved in defence research.

Nearly ten years of cooperation in R&T at the EDA have shown that effective multilateral cooperation is possible. These successful cooperations fall into two categories:

- Cooperation on defining a standard based on the development of a technology, a standard from which all States and all manufacturers may benefit without affecting the conditions of competition. This is the case for the MIDCAS programme, a Category B project comprising France, Germany, Spain, Italy and Sweden, which should enable future drones to be integrated into non-segregated airspace. This project is one of the technological building blocks of the Remotely Piloted Aircraft System (RPAS) programme, which also involves the ESA and Eurocontrol. This standard should enable Europeans to enjoy a technological edge in integrating drones in air traffic.

- Cooperation on a generic technological building block. This is the case, for example, for the research programme on gallium nitride, an essential component of radars that will benefit both Thales and Selex Galileo, which are rivals in this field. The cooperation is considered a success if competition between the companies is not affected: all the companies participating in the programme benefit from the results of the research.

As seen in these last two scenarios, the positive impacts of this cooperation are limited in that they do not necessarily bring about industrial consolidation. It should also be noted that R&T cooperation within the EDA can result in programmes whose scope may differ from the original scope. This is what happened with the Category B Maritime Mine Counter Measure

(MMCM) programme [16] which is now being developed within a Franco-British framework.

La Commission européenne

The European Commission has jurisdiction over security research under the framework programme for research and development (FPRD). The 7th FPRD, which covers the period 2007 to 2013, includes a dual-use security research component. The 8th FPRD, or Horizon 2020, will likely expand the research framework to other sectors such as Key Enabling Technologies (KET), which can have both civil and military uses.

There are five characteristics to cooperation under the 7th FPRD:

- it concerns dual- and non-dual-use defence technologies in a programme dedicated to security technologies;
- it should encourage European rather than national research. European consortiums must therefore be formed to present projects;
- the Community financing is granted in the form of subsidies;
- the cooperating companies must contribute 50% of the funding for the research programme;
- the cooperation does not result in the manufacture of a product.

For the forthcoming 8th FPRD, named Horizon 2020, the European Commission would like to move away from the purely subsidy-based mechanism. It would like to both own the access rights to the technologies developed and make acquisitions in the future.

As such, it has introduced the pre-commercial procurement (PCP) approach. PCP could, in particular, concern dual-use technologies with projects that have been funded within both the Community framework and the EDA framework. This could be the case for the CBRN programmes in protection, for ESSOR with the future software-defined radio and for RPAS with drones, projects that now serve as the framework for cooperation between the EDA and the European Commission via the European Framework Cooperation.

Industry supports PCP, as it would create new opportunities for new products. But the question of intellectual property rights (IPRs), which the Commission would like to own when it has funded the research, raises concerns among manufacturers in terms of the dissemination of technologies and the development of competition.

This property rights question is a recurring one in R&D cooperation and/or pooling, as public entities and private entities have different interests. In defence and security, States would like to have the right to access the results to continue to develop the technology they have funded based on the sovereign mission of protecting the security of the State. Companies, for their part, would like to own the property right because they have developed the technology and because this goes to the very heart of what makes a company valuable. Disseminating the technology reduces the company's competitiveness.

[16] Project comprising France, Belgium, Estonia, Finland, Germany, the Netherlands, Poland, Portugal, Romania, Spain, Sweden, the United Kingdom and Norway.

Moreover, while it appears reasonable to expand the scope of the European Commission's action to dual-use technologies, particularly for low TRLs, as will be the case for Horizon 2020 with Key Enabling Technologies[17], this could prove more difficult for defence technologies, no matter the scenario:

- 1st *scenario: the current financing mechanism for security R&D is expanded to defence research.* In theory, companies will not agree to expand the current co-funding mechanism for dual-use research to defence research because they believe that defence is not a fully open and transparent market and that they would not develop defence technologies if there were no demand from States based on security considerations. For the most part, they will therefore have no desire to support a mechanism that would be tantamount to endorsing the principle that companies can self-fund defence research;

- 2nd *scenario: Defence research is funded via subsidies from the European Commission with no financing provided by the companies.* In this scenario, the European Commission funds all defence research through subsidies. It might be assumed that the European Commission would request substantial compensatory measures relating to the European Union's and its members' right to access the results, which could dissuade companies, as well as the largest countries, from supporting such a mechanism. The situation would be similar to the European Defence Agency's Category A research programmes, which have met with little success. This solution therefore seems possible only for the funding of key defence technologies at low TRLs, where the question of the utilisation of the products of the research does not arise.

- 3rd *scenario: defence research is funded based on competitive bidding.* Until now the States and companies have opposed subjecting research and technology contracts to competition because these contracts are excluded from the scope of the directive on defence and security procurement. Additionally, the European Commission does not currently have contracting authority capabilities for the development of applied defence technologies.

What now appears to be the most likely and most promising approach to pooling is a joint effort by the EDA and the European Commission on programmes involving dual-use technologies under the European Framework Cooperation. Through these cooperation, projects — like the one concerning protection against CBRN threats — can be funded by both the European Defence Agency and the European Commission's FPRD, with the Agency acting as the contracting authority.

Beyond the technical considerations, the issue of the pooling of defence R&D is tied to the level of integration of the European Union. As the European Union makes strides toward integration and moves closer to having a joint defence and security policy, an elected

[17] Communication from the European Commission, A European Strategy for Key Enabling Technologies, A Bridge to Growth and Jobs, 26 June 2012. Key enabling technologies include research in micro-/nanoelectronics, nanotechnology, photonics, advanced materials, industrial biotechnology and advanced manufacturing technologies.

executive authority and a consolidated and restructured European industry, it will become easier to pool defence research and development at the Community body level.

What can currently be expected from the pooling of defence R&D is better streamlining of technological innovation in defence and the beginnings of the industrial consolidation, which can only truly take place at the development stage in high TRLs and through joint armament programmes. ■

Appendices

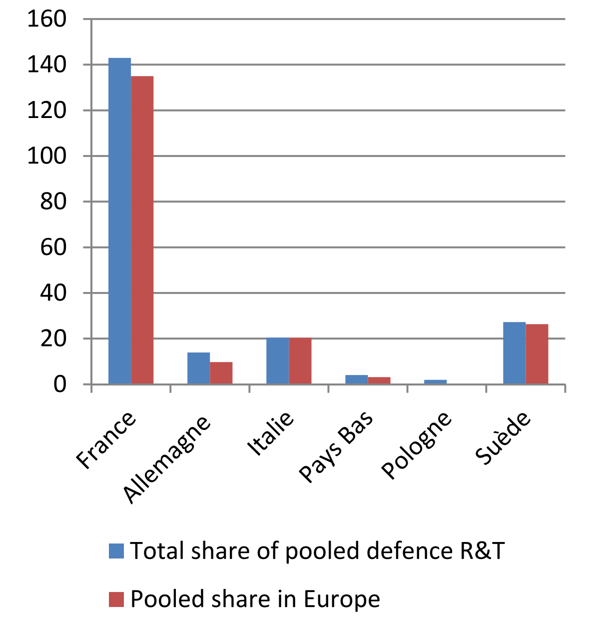
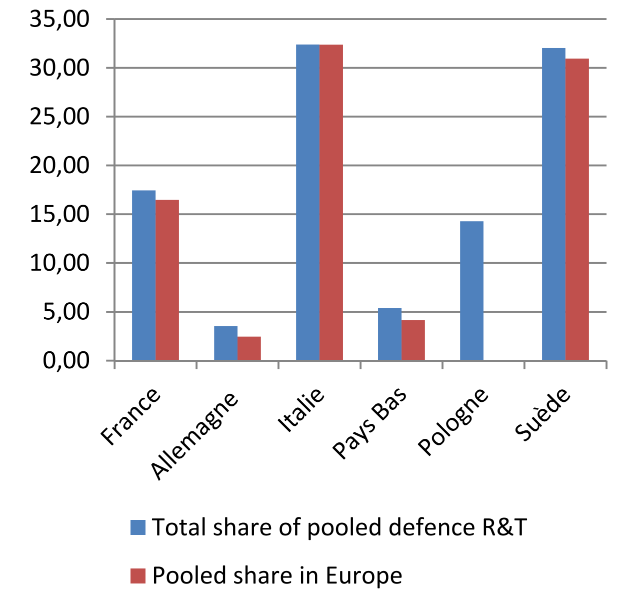
Annexe 1 – Defence R&D and R&T Spending and Pooling in Europe in 2010

	R&D	R&T	R&T/military spending
	€ millions		
France	3,580	820	2.09%
Germany	1,455	394	1.18%
Italy	64	-	-
Netherlands	75	74.7	0.88%
Poland	121	13.9	0.21%
Sweden	107	85.9	2.01%
United Kingdom *	2,895	526	1.33%

* Year 2009

Source: National Defence data 2010, 7 March 2012, European Defence Agency

Annexe 2 – Pooling of Defence R&T

Pooling of defence R&T (EDA data for 2010)[18]	
€ millions	as % of defence R&T
	

Source: National Defence data 2010, 7 March 2012, European Defence Agency

[18] Data are not available for the United Kingdom. However, interviews conducted for this report lead us to estimate the amount of pooled R&T in the United Kingdom at approximately €150 million, of which approximately €110 million with the Americans.

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