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Jacques Fontanel

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## **Military research and development.**

### **United States and Europe comparisons**

**Jacques Fontanel**

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Geoeconomics, International Conference on Conflict Management Peace Economics and Peace Science, Jan.8-10, 2010, Sponsored by Indira Gandhi National Open University (IGNOU), New Delhi, India, in Cooperation with Gandhi Smriti and Darshan Samiti, New Delhi, India Economists for Peace and Security, Peace Science Society (International), International Center for Conflict Prevention and Management, Sydney, Australia, Binghamton University, State University of New York at Binghamton, U.S.A.

Abstract : For the government of the United States, the supremacy of the military R & D is an indispensable condition of a sufficient military power to fight, by dissuasion or the force, the political regimes and the countries likely to be opposed to the Western democratic values or to compete with the national economic interests. The research and development of the United States accounts for 40% of the world expenditure in the sector and more than one third of the new patented inventions. In Russia, the considerable military expenditure of the Soviet period was not renewed any more. Since the end of the cold war, this expenditure decreased mainly in of Germany and France. Several controversies took place concerning the research and development in the world. They relate to the existence of a military-industrial complex, the effects negative of military expenditure on the economic growth, the attitude of “stowaway” of Europe taking into consideration expenditure of defense of NATO, the economic efficiency of the R & D military and the increase in delay in the R & D military European.

Words : R&D expenditures, Europe, USA, NATO, Russia,

Today the United States is the world military great power. After being condemned per many strategists to the decline and in spite of its responsibility in the world financial crisis, the hegemonic image of the United States is not erased in the human consciences and analyzes. Since 2001, the American military expenditure increased by 60% in constant dollars, to reach 720 billion dollars in 2009 (540 billion dollars of budget plus 170 billion dollars for the wars in Iraq and Afghanistan and ten billion dollars for the budgets defence out the DOD, the Department of Defense).

After a significant reduction of R & D military expenditure after the end of the cold war, the government of the United States was engaged in the “war against terrorism” (after the attacks of September 11th, 2001) and the

denunciation of the ABM treaty. The military expenditure, after having known drastic reductions in the years 1990, is again increasing<sup>1</sup>. In comparison with the United States, China (122 billion dollars), Russia (70 billion dollars), the United Kingdom (55 billion dollars), France (54 billion dollars), Japan (41 billion dollars), Germany (38 billion dollars) or Italy (31 billion dollars) appear relatively weak, if it is considered that each dollar spent has the same military effectiveness. For European Defense Agency, the government of the United States spends twice and half more in the area of defence (1640 euros per capita) than the European Union (412 euros per capita). If the US government agrees to spend more than 4,5% of its GDP to finance soldiers (including the committed wars), Europe is satisfied overall with 1,8% which testifies to its reduced interest for the military power itself, on the basis of an analysis in terms of opportunity costs for today and tomorrow.

Since the birth of NATO, an important delay exists between the financings of Europe and those of the United States concerning the military research and development expenditure. This question was the subject of a debate relating to question of the division of the burden of European defense. In 1975 already, the Callaghan Report/ratio underlined the imperfections of the system, with the description of the European duplication of the efforts of R & D, the insufficient production series and thus the unexploited potential of the scale economies. It recommended a rationalization and a specialization of industries of defense inside NATO, as well as an effort to develop the technology transfers towards the civil productions (and vice versa). The difference between the military R&D expenditure of the United States and those of Europe grows for all the period of the Bush.Jr presidency.

It is thus interesting to give an objective a report on the places and to highlight the controversies on American military hegemony and the choice of Europe to incarnate an economic alternative to the strategic power of the United States.

### The inventory

For the government of the United States, the supremacy of the military R & D is an indispensable condition of a sufficient military power to fight, by dissuasion or the force, the political regimes and the countries likely to be opposed to the Western democratic values or to compete with the national economic interests. There exists in the United States several scientific agencies of technological programs, of which most known are respectively MDA (Missile Agency Defense) specialized in technologies of the missiles and DARPA (Defense Advanced Research Projects Agency) engaged, in the name of Department of Defense, in the riskiest fields of the close relationships

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<sup>1</sup> In 2009, the total budget devoted to the U.S. military R & D exceeded 80 billion dollars (in increase of 75% compared to 2000), that is to say the total budget of the military expenditure of France and Spain.

maintained between the potential basic research and military applications. Moreover, the department of energy is responsible for the program of the nuclear weapons and the fuels concerning the nuclear submarines. The sums engaged for this reason in R & D exceeded 5 billion dollars in 2009.

In the field of the research and development, the variation in 2009 was even more important, about 80 billion euros for the United States against a little more than 10 billion euros for the unit Europe, that is to say eight times less. The effort of the US governments as regard military R & D is thus considerable. It accounts for 60% of the Federal state R&D expenditures.

Table 1 - Budgets of the American defense of R & D military for the financial years of 2007 and 2009 of billion dollars (Source: interpretation of the presentation of: AAAS R & D FY 2009-53).

Expenditure	2007	2009	Military R&D/ Total R & D 2009
Basic Research	1,53	1,71	6,1
Applied Research	7,78	6,61	23,9
Development	73,00	75,78	88,7
Management	0,39	0,42	8,92
Total R&D	82,66	84,61	57,40

In a way surprising taking into consideration usual request of the Pentagon, Department off Defense (DoD) increased its effort as regards basic research, in particular in direction of the universities. DoD becomes the fifth financial support of research in physical sciences; it finances more than 30% of sciences from the computers, 30% of oceanography and 14% of mathematics with federal finances. Its role is even increased in the field of mechanical, electric engineering or materials. This research has positive effects on the civil sector. In 2009, DoD is the third financial support of the Universities and colleges, after the National Institutes off Health (NIH) and the National Science Foundation (NSF). The budget 2009 defines an inflection taking into consideration preceding budget, by supporting the basic research.

If the applied research knows a reduction of received public finances, the cause is not founded on a rejection, but rather on the collective effort that the public authorities required of the Ministries in order to reduce the public debt. On the other hand, the development programs knew a big rise in the financings of federal research, in particular in favour of the air force. Among the agencies of defense, the Missile Agency Defense (MDA) remains the financial line most important (nearly 9 billion dollars). This research is often put under the responsibility of important private contractors of defense, like Lockheed Martin or Boeing, but also of the laboratories of defense, FFRDCs (Federally funded research and development centers, or centers of R & D financed by the Federal

state)) and of the universities. For the government of the United States, supremacy in R & D military main road is an indispensable condition of a sufficient military power to fight by dissuasion or the force the forces and countries likely to be opposed to the democratic values or to compete with the national economic interests.

Table 2 - The comparison of the expenditure of defense of R & D (in million current dollars (Source: Derived from OECD, 2007)

Countries	1991	2000	2003	2007
France	5302	3237	4196	4500
Germany	1690	1292	1168	1100
U.K.	3623	3760	4322	4400
USA	39341	43144	54629	80000

The European efforts of collaboration in the field of research, in particular military, were numerous. The IEPG (Independent European Programs Group), the forum for the European co-operation of the armament implemented the program EUCLID R & D ((European Cooperation for the Length-Term in Defense), then in the years 1990 it was replaced by the WEAG (Western European Armaments Group) which allowed an easier co-operation on the basis of EUROPA Memorandum off Understanding. Since December 1998, the European Union institutionalized the ESDP (European Security and Defense Policy) engaging of new collective investments in the military research and development European. However, all the countries do not take part in the same way in this program. The States remain the most important actors in the financing of European safety. Thus, France and the United Kingdom account for 50% of the total military expenditure, Germany contributing to a total value of 16% of this total. Moreover, the means placed at the disposal of the ESDP do not reach 50 million dollars, which does not offer a great possibility of development. The EDA (European Defense Agency) was created in July 2004 in order to improve the capacities of European defense in the field of the management of the crises and the support of the ESRP, the co-operation as regards armament, the organization of base of an industrial and technological defense for Europe and the research and development.

Coarsely, the research and development of the United States accounts for 40% of the world expenditure in the sector and more than one third of the new patented inventions. It employs 1,3 million people, among whom 70% of the Nobel Prize and the best scientific universities. The military research and development accounts for 60 to 80% (taking into consideration dual research) of the expenditure engaged in this sector by the Federal state and 40% of the total research effort of the United States. These figures testify to the importance to the R & D military engaged by the US government. However, the application of

military technologies to the civil sector was often criticized and the example of the collapse of the Russian military-industrial complex testifies to this improbable relation. The importance of the committed sums highlights the financial capacity of the United States to develop the new generations of powerful weapons, at the same time offensive and defensive. Two principal directions are proposed today in the allowance of the expenditure of R & D. Initially, it is appropriate to explore the new niches in the sector of the armament, for example the development of the new generations of nuclear weapons necessary to the period of after cold war, even if the immediate interest for the civil sector is not proven. Then, the State must support emergent technologies of the public sector that will be able, then, being applied to the military sector, like robotics or biotechnologies.

The military research and development costs very expensive and more and more expensive. The ratio of the costs of the development of a fighter was multiplied by 100 since 1980 that is to say of 4% per annum, because of the development of electronics. In Russia, the considerable military expenditure of the Soviet period was not renewed any more. However, the expenditure of R & D was reduced and is limited to the nuclear sector, aviation (often of coordination with the American companies) and to the space sector. For Europe, the military expenditure of R & D are at the same time limited and very concentrated around the six principal military powers, including more than 60% for France and the United Kingdom. Since the end of the cold war, this expenditure decreased mainly in of Germany and France (in spite of a start since 2001).

The variation is due to several causes:

- Initially, the strategic analysis of the two powers differs. If the government of the United States feels invested a world mission and he considers, in addition, that it is a need for its national security. In this context, he seeks a military form of domination that is expressed initially by a technological superiority, in particular with regard to the emergent powers (China) or of the threats related to the anti-Americanism growing in the world caused by the wars in Iraq and Afghanistan. Considerable financial liabilities in the field of research on research concerning national defense against the missiles bring the proof from there. The United States is convinced of the importance of technology in the future wars and for the operations of maintenance of peace. In 2001, Four-year Review Defense called with the Revolution in Military Affairs. He insisted on the objective of the technological domination of the United States in the military field. For Europe, the strategic considerations differ between the countries, between those which wish to preserve the nuclear weapon and those which condemn it, the countries turned towards the Atlantic coalition and those which wish the respect of neutrality, the States which wish to preserve the attributes of the power at those which assert more humanistic values founded on the equality of the people in the democratic management of the world. The first attempt to

develop a common European analysis, the CFSP (Common Foreign and Security Policy), near to the American preserving theses, highlighted the dangers of terrorism, the organized crime and the proliferation of the weapons of massive destruction. Europeans generally do not wish the refusal of the treaty anti-missile and they are basically worried regional conflicts and crises. Under these conditions, they insist rather for a production of robust weapons, which often replace the obsolete weapons in their making progressive improvements directly. It is not question of developing new weapons then, initially because the needs for defense are ensured overall by the weapons available, because financial means and the technological efforts made by the Americans do not seem with the range of Europe which is worried more its interior peace to become a gendarme of the world.

- Then, in Europe, the expenditure of research and development remains basically national, according to different institutional methods, even if certain programs scientific and technological military European exist. Contrary to the United States, France and Germany call upon the university research little. On the other hand, if the R & D military of France were organized or coordinated by the General delegation of the Armament, Germany organizes itself around independent research institutes and of the private firms.

The role of the European commission in the financing of the R & D is reduced, often founded on dual research (military and civil). Its contribution does not exceed 5% of the total expenditure engaged in the sector. At the bottom, the available resources are dispersed in several national plans. That does not want to say in so far as the financed operations are ineffective. On the contrary, taking into consideration versed considerable sum in the United States, the scientists seek with better making profitable the financings that are entrusted to them. In the American system, several reports/ratios underlined the delays, the over costs and the real performances quite lower than those which were programmed in the beginning. A surplus production capacity and doubled blooms also exist in a system of competition reduced, which obliges the State to support financially, directly or indirectly, each research center. Because of the big risks taken by the DARPA, the level of failure is much higher in the United States than in Europe. Lastly, the American budget is the subject often of desires of predation that lead the lobbies to obtain contracts whose utility or relevance (in the competing or financial plan) makes debate.

## Controversies

Several controversies took place concerning the research and development in the world. They relate to the existence of a military-industrial complex, the effects negative of military expenditure on the economic growth, the attitude of “stowaway” of Europe taking into consideration expenditure of defense of

NATO, the economic efficiency of the R & D military and the increase in delay in the R & D military European.

- In the United States, an intense effort of lobbying - with the initiative of the military-industrial complex denounced higher by the Eisenhower- General was born in order to diffuse the idea widely than the military innovations, and thus the expenditure of R & D which are in the beginning, has well vocation to find applications in the civilian. An important debate always takes place on the utility of the military-industrial complex, between those which considered paramount its negative effects (loss of competitiveness and over-development of the bureaucracy) leading to a permanent state of war and those which insisted on the economic need for a sufficient national protection. The study of Beach and Foertsch considers that the American military expenditure rather has a positive effect on the national economic growth, thus underlining the effects a keynesian effect of military expenditure and, later on, the interest of the expenditure of research and development for the economic and technological competitiveness of the country.

- For the government of the United States, Europe does not do sufficient effort in the military field, in particular in the field of the R & D. They dispute the individualistic character of Europe protected by NATO at a cost quite lower than its real costs, with the expenses of the American taxpayers. The US government asked with force for the increase in the military effort of its European allies, without much success. Inclinations of development of the European base of R & D often seemed to have more success near the governments within the framework of a transatlantic total co-operation (even if all the European countries do not share this point of view, in particular France of before the Sarkozy presidency) that the national companies fear. However, with stronger technological capacities of Europe would reinforce this political continent and would improve its security conditions, partial independence in the long-term included/understood. In this context, the States must admit a certain form of dependence and become an importer of military materials of the allied countries and an exclusive exporter or not for others weapons towards these same allies. However, it is to forget a little quickly that the financing of NATO is weak and that in an indirect way, taking into consideration its omnipresence in the transatlantic institutions, the United States takes the European expenditure of defense as an hostage and use them, at least partially, in their military and diplomatic demonstrations of dissuasion. This "sensitive to the cold" position of Europe explains also the development of the tendencies unilateralists of the United States and the scepticism of frontage concerning the military value of alliances.

- However, a too important variation in military technologies in its discredit poses the crucial question of the survival of an industrial base of European defense, and thus of its policy and its independence. This insufficiency of financing of the R & D disadvantage European companies, in



particular those, which engage in dual technologies or co-operations with American firms. It is often allowed that the US government engages an industrial policy via the financing of national defense, in particular in the fields of electronics, aerospace or of the metallurgy. The large firms like Lockheed Martin, Boeing and Northrop Grumman are the large recipients. Today, Europe knows a movement towards the privatization of the companies of armament, the search for a consolidation of the industrial bases and the Europeanization of the firms. However, the companies refuse to share their scientific information and technological and the common programs often were of the failures partial taking into consideration notion and accumulated delay, difficulty of negotiation of the “just reward”.

- For Ruttan, the military sector can more easily than the civil sector to reveal the major innovations that develop the economic growth, by developing the productivity in particular three assumptions are generally advanced concerning the effectiveness of the R & D military. Initially, the effect of ousting with civil research is not really realized, except for the totalitarian States. Then, the technology transfers towards the civil sector are not always proven if one refers to the patents. However, in spite of the great vice of financial efforts devoted to defense, part of this wasting in terms of productivity comes to question current technologies and tend to transform them radically. Lastly, the effect “requires” leads to an acceleration of the forces of the innovation. However, the R & D military are not very profitable in the short run. In the case of Russia, it caused an effect of ousting considerable on the R & D civil. The marketing of the military products or defense always does not have obvious civil commercial applications, taking into consideration specificity of the materials, new investments to engage and character sometimes “baroque” of technologies used. The reconversion of industries of armament always presents considerable economic difficulties, because of inadaptability of the fixed assets, the existence of a strong competition on the markets specialized and of the low potentials of fast reaction of the marketing of a product on a market without new adapted innovations. Especially, she encourages a type of technological development and innovations private individual that can then influence the whole of the civil production with shifts of one or more decades. Thus it was with the nuclear sector, data processing or Internet.

- In the short run, the R & D military do not constitute any more the principal pivot of the technological advancements of the country. The United States is in advance in the majority of the sectors having a direct interest for defense, in particular in the scientific computers, the aerospace one, the machine tools and the instruments of communication. The American companies ensure the world service sector of high quality for a third at least. Europe remains the principal rival even if the efforts of China as regards research and development are considerable. Today, research is characterized by three principal injunctions: it is more and more deprived, globalized and organized in collaboration. Under

these conditions, it is necessary to take into account the fact that the technological capacities are more widely diffused with the potential candidates, other than the military sector, often still cut off in philosophy from the secrecy, the access to the most advanced technologies is not guaranteed more to the only American territory and the domination of the United States in this sector, in spite of the engaged important sums, is not assured any more. Indeed, with the opening of the commercial and financial borders, the fast diffusion of the technological advancements reduces the importance of the technological delays of the economies of the other countries. At the bottom, the expenditure of R & D of the United States would be, with a tiny time, generalized with the whole of the globalized productions, conferring to them, at least partially, the denomination of international public goods. It is necessary to develop foreign technological developments in order to avoid the omission of particularly important new technologies for future economic development. This characteristic applies less better to the military sector, which modifies gives it concerning the maintenance of the technological superiority of the United States, at least in the sectors, less and less many, where the research and development of the sector of defense is in advance on the civil sector. It results from it a relative decline from science and American technology, even if it remains still dominant. The scientific prosperity often dominated successively by nations over one 80 years period, Italy of 1540 to 1610, England of 1660 to 1730, France of 1770 to 1830, Germany of 1830 to 19120 and the United States since more than 80 years. Today, the scientific prevalence of the United States is the subject of debates, but the domination of the American Universities does not seem compromised. However, the scientific discoveries are at the base of the technological advancements and economic. This weakening is a threat for the standard of living of the Americans. The fast transmission of technologies in a reduced world globalized the importance of a technological leadership and constantly calls it into question. The American students are less and less interested by hard sciences contrary to the students Indian or Chinese and a big number of those follow studies to the United States and return then on their premises. The effort of the federal government towards the universities and the R & D military can be also explained by this erosion of the technological advantage of the United States in the scientific disciplines and technological.

- The US government benefits from the very limited control of the World Trade organization in the fields of defense to provide a substantial help at the same time to the firms also producing civil materials and to the research laboratories to improve technological knowledge at ends of national security, certainly, but also of improvement of the civil products. This controversy was often committed, which supposes that the funds offered benefit dual technologies and reinforce the competitiveness of the private firms placed in a world context of commercial competition. It is certain that the military sector stimulated civil technological developments in the fields of the semiconductors,

data processing, the nuclear power or aerospace industry. The sector of the R & D military, by its importance, gives substantial means to the scientists and to the engineers, thus improving the national base of knowledge likely to be applied to the civil field.

- The European Security Research Programme (ESRP) must lead to a progress in the European policies of safety, mainly rather with a view to a better effectiveness of the expenditure of R & D than in the rise of the specialized military expenditure. An effort of Europe should lead it to obtain important instruments for better working its future, in particular political, but it does not seem to want to take this route. Its own strategic prospects do not fit in a philosophy and objectives similar to those that prevail in the United States. Today, of the programs headlights out of matter of armament are launched: during the years 1999-2001, Europeans are involved in the military program airplane transport A400M, in order to reduce their logistic dependence considerably. Other armament programs, like the missile METEOR, 1 or the navigation system by satellite GALILEO must give to Europeans means comparable with those of American. Moreover, these co-operations deploy a structuring effect on the industrial landscape of defense. Indeed, they have not only one political and military advantage in the direction of a better interworking and d'un bringing together between the States, but they also make it possible to share the costs and to structure of the poles of excellence. Today, Germany does not seem to have the ambition of an increased financial effort are equivalent at least to that of France or the United Kingdom. Many efforts were however made, as the proof from there the many programs in this field bring, whose multiplication highlights their limits. However, the co-operation between the European countries as regards military research is potentially limited. The national plans of importance are the subject already of many negotiations between the social actors, while at the same time the concepts of national public goods are finally rather clearly defined. The national interest remains paramount.

The "singing of transatlantic sirens" limits this collective European effort. The "Eurofighter" program to which the "fair return" rule is applied is based on an "equal partnership". Each participating state has an assembly line and a support center that allows the integration of new weapons and changes to the operational software, thus guaranteeing the autonomy of use of the device. These conditions nevertheless create industrial overcapacity and unnecessary duplication, leading to delays and additional costs: the dispersion of industrial capacities reflects the inability of the arms producing states to agree on less expensive cooperation practices. However, in the United States, the Eurofighter appears as a serious competitor. The purely European program reinforces the fear of a marginalization of American builders. Faced with this "threat", the Pentagon reacts with a particular "strategy": to ensure access to the European market and avoid the emergence of a competing program of the F-35 / JSF, the

objective of the Pentagon is to appeal to international cooperation. The DoD targets "interesting" states and offers them to join in funding the various phases of the F-35 program, from R & D to support. In order to rally the Europeans to the American vision of things, the US is banking on the attraction of new technologies and is launching a real charm offensive. Finally, the United Kingdom, Italy, the Netherlands, Norway and Denmark are being convinced. The cooperation of Europeans is supposed to be primarily financial. For the partner countries, it is the amount of their contribution that determines their level of access to information, the possibility of influencing the specifications, the participation of industries in tenders as well as the possibility of benefiting a reduction of costs in case of acquisition of the aircraft. This structure based on financial participation allows Americans to kill two birds with one stone: if it offers the DoD (US Department of Defense) new resources and therefore the opportunity to share costs, it also offers the advantage of drying up the R & D budgets of signatory states over the long term, slowing down their ability to finance competing programs. It is not surprising that the impact of technological spillovers is very low for Europeans. It's no longer a secret that Americans are reluctant to share their technology. Information transfers generally do not focus on sensitive and innovative technologies that ensures the superiority of the leading country and places other participants in a position of dependence on it. Thus, in the framework of the F-35 program, the implementation, the support and the adaptation of the aircraft remain under American tutelage. This question is at the origin of an important dispute between London and Washington. The United Kingdom wants the F-35 aircraft code to guarantee its operational sovereignty. This computer data is essential to develop the aircraft and integrate British systems. The Americans, however, refuse to give the code for intellectual property issues and fear that it will be copied and used in European programs or for competing radar systems. Despite British threats to withdraw from the group, the Americans have still not yielded. Finally, by soliciting a contribution that represents a large part of the partner countries' defense budget over the next ten years, the United States limits the possibilities of large states like the United Kingdom and Italy to finance European projects in parallel. and respect their command intentions of the Eurofighter

In fact, this delay in military R & D begins to raise the question of interoperability and therefore of the willingness of the United States to continue its effort, partially captured in the framework of a "stowaway" type procedure, by the United States. Europe. Some European countries are starting to bow to this collective resignation, which is reducing the competitiveness of military technologies and the short-term or long-term commercial benefits associated with them. In fact, these two arguments are of course opposite. Developments in the nuclear field remain important, because the strategy of the United States with respect to Russia or China can not avoid this technological confrontation.

This is to maintain this strategy both to protect the "free world" and to deter potential adversaries.

There is today a "vulgarizing" of the industry of defense, which would be structured by the needs for the United States. For the United States, there exists a recognition according to which science developed with lower costs in other countries and that the delay of those was reduced. They recognize the need for differently interpreting the performances of research and they open with international collaborations. The mobility of the foreign researchers in the United States is clearly encouraged. There thus exists an pro-active policy which seeks to preserve an economic power and soldier of the hegemonic type. The R & D military European are late compared to that of the United States. The diagnosis is simple: in spite of important reorganizations, they n exist not of true industrial base of European defense, which constitutes for as much a true economic imperative in a situation of international competition. The constitution d'un such economic base essential to a really autonomous PESD represents a real challenge. In 2004, the EDA (European Defense Agency) was created with a view in particular to promote the co-operation of the R & D military. This organization always had as an aim to be dissociated from a too great dependence of the United States and to reduce the potential of "brain drain" towards the military research organizations good equipped and to the high wages. Nevertheless the accumulated delay seems considerable today.

here is today a "trivialization" of the defense industry, which would be structured by the needs of the United States. For the United States, there is a recognition that science has developed at lower cost in other countries and that the backwardness of science has diminished. They recognize the need to interpret research performance differently and open up to international collaborations. The mobility of foreign researchers in the United States is clearly encouraged. There is therefore a pro-active policy that seeks to maintain a hegemonic-type economic and military power. European military R & D is lagging behind that of the United States. The diagnosis is simple: despite major restructuring, there is no real industrial base for European defense, which is a real economic imperative in a situation of international competition. The constitution of such an economic foundation, essential for a truly autonomous ESDP, is a challenge today. In 2004, the EDA (European Defense Agency) was created with a view notably to promoting the cooperation of military R & D. The goal of this organization has always been to distance itself from over-dependence on the United States and to reduce the potential for "brain drain" to well-endowed military research organizations and high salaries. Nevertheless, the accumulated delay seems considerable today.

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