

Reassessing the “Guns and Butter” debate: the role of military revolutions and defense industry innovation in contemporary spatial development

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Abstract

The role played by innovation and knowledge in fostering development in contemporary society is today unquestionable. However, knowledge is not a key-factor merely in the economic realm. In recent years there has been an intense debate as to the nature of changes inside the military establishment, which is greatly transforming weapon systems, strategic doctrines, and the military organization as a whole. This study analyses the affects of this Revolution in Military Affairs on the international defense industry. The attention given to innovation in the defense industry is a prime concern to manufacturers, military establishments, and governments. We conclude that R&D and innovation in the defense sector play an important part in many countries National Innovation System (NIS) and spatial development.

Key-words:

Defense industry;
Innovation;
Revolution in Military Affairs;
Spatial development.

Resumo

O papel desempenhado pela inovação e conhecimento no desenvolvimento da sociedade contemporânea é hoje inquestionável. Todavia, o conhecimento não é um factor-chave somente no domínio económico. Nos últimos anos tem-se gerado um intenso debate sobre a natureza das transformações registadas nos estabelecimentos militares, que alteram profundamente os sistemas de armas, doutrinas estratégicas e a instituição militar no seu todo. Este estudo analisa os efeitos desta Revolução nos Assuntos Militares na indústria de defesa internacional. A atenção prestada à inovação na indústria de defesa é uma questão importante para os fabricantes, instituições militares e governos. Concluímos que a I&D e a inovação no sector da defesa desempenham um papel importante nos Sistemas Nacionais de Inovação e no desenvolvimento territorial de muitos países.

Palavras-chave:

Desenvolvimento territorial;
Indústria de defesa;
Inovação;
Revolução nos Assuntos Militares.

I. Technological Change and Military Revolutions

The role played by innovation and knowledge in fostering development in contemporary society is today unquestionable. Since Paul Romer's "New Growth Theory", knowledge has established itself, next to labour and capital, as one of the leading factors of production. Although knowledge is not a novel commodity, the present speed of its production, accumulation, and diffusion has given it a sweeping potential. A wide range of studies reveal how knowledge has transformed itself into the main source of prosperity for many individuals, corporations, and nations (M. Castells, 2002; G. Clark *et al*, 2003; P. Drucker, 1994; D. Landes, 1999; L. Thurow, 1996). The structural transformations registered since the 1970s have placed a tremendous value on investigational activities. Therefore these have become indispensable to the creation and expansion of the present-day "knowledge economy".

Behind this transformation of contemporary society, according to the European Commission (2003: 1), three new "key-technologies" have had an unparalleled catalytic influence:

- Information and Communication Technologies (ICT);
- Biotechnology;
- Nanotechnology.

The importance of these technologies derives from their capacity to generate new technologies and influence profoundly existing ones, impelling deep transformations on the present and future social order. This distinct group of technologies is strategically associated with the creation of new products, processes and jobs. Their application and interaction have significantly transformed our

understanding and perception of the process of innovation. Traditionally innovation was understood simply as the ability to discover new technologies. Today it comprehends the systematic exploration of new combinations of existing knowledge.

However, knowledge is not a "key-factor" merely in the economic realm. The implications resulting from the referred transformations are felt throughout the various dimensions of contemporary society. Bearing in mind that "economics and power are closely related" (D. Alberts & R. Hayes, 2003: 71) it is not surprising that the armed forces are highly influenced by these same transformations. As a result, there has been an intense debate in recent years as to the nature of that change inside the military establishment. Many military scholars are even referring to this phenomenon as an authentic Revolution in Military Affairs (RMA), greatly transforming weapon systems, strategic doctrines, and the military organization as a whole (E. Cohen, 1996; .F. Kagan, 2005; A. Krepinevich, 2005; R. Scales Jr., 2000).

Since the 1991 Gulf War many authors have been calling attention to the revolutionary pace and impact of innovations and transformations in information technologies, computational sciences, and weaponry in general. Nevertheless, as Andrew Krepinevich (2005: 214) has stated, the allied intervention in Iraq should not be considered revolutionary because it revealed neither a dramatic doctrinal transformation nor a substantial modification of force structure or of the military organization. Yet, Operation Desert Storm did allow a glance at the potential influence of these technological transformations in

the future of military affairs. In this sense it was a “precursor war” in that it was “an indication of the revolutionary potential of emerging technologies and new military systems” (*idem: ibidem*). Notwithstanding this observation, the new realities observed in the armed conflict in the Persian Gulf did make officials in Washington think about the implications of these new technologies in the future of warfare.

Since the beginning of the 1990’s there has been a serious enquiry into the implications of technological transformations in the armed forces. Although the concept of RMA has turned into somewhat of a “buzzword” inside the defense establishment (W. Murray, 1997: 69), and despite the fact that the George W. Bush Administration has recently preferred to apply the term “defense transformation” (A. J. Telo, 2006: 15), the changes observed in recent years certainly warrants a deeper examination of its effects on the future of the armed forces in particular and society in general.

As history has confirmed time and time again, periods of great change in the military realm usually correspond to greater changes in society at large. According to António José Telo (2002) and Paul Hirst (2001) history has witnessed three great military revolutions, coinciding with wider socio-economic revolutions. The first corresponds to the transition from medieval society, with its fragmented power centers, to modern society, with highly concentrated power in the hand of the States. The second revolution corresponds to the subsequent transition to industrial society. Lastly António José Telo identifies the present military revolution as being analogous to the transition from industrial society to that of information and knowledge.

Although the debate around past and present RMA is not at all consensual (M. O’Hanlon, 2000), it is fair to assume that the present situation greatly resembles the definition submitted by the Director of the Office of Net Assessments of the US Department of Defense. Accordingly, a Revolution in Military Affairs refers to a “major change in the nature of warfare brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and operational and organizational concepts, fundamentally alters the character and conduct of military operations” (J. McKittrick *et al*, 2002: 37)¹.

As already mentioned above, the change in question results many times from larger transformations in society. Eliot Cohens suggests that “dramatic changes in warfare occur as a consequence of forces endogenous to war” (1996: 41). Nevertheless, for the author there are two essential exogenous developments responsible for the present military revolution. The first is related to the rise of information technologies, which have affected the military establishment deeply, whether through the creation of “intelligent weapons”, intelligence gathering and processing, or in prevention and surveillance activities. The second big development is in the diffusion of the capitalist system throughout the globe. The present requirement to rationalize and optimize the diverse resources available has led the armed forces to search for external sources to satisfy their service and/or procurement needs. The demands of the market and post-industrial society thwart continuing the practice of “military socialism” that endured throughout the Cold War (*idem*: 43).

Regardless of the multiple exogenous factors influencing the contemporary military

organization it should be stated that the role attributed to the technological revolution has been unsurpassed in the thematic literature. Consequently Jeffrey McKittrick *et al* (2002: 43-53) have identified four new warfare areas resulting from the application of the technological revolution to the military sphere: Precision Strike; Information Warfare; Dominant Maneuver; and Space Warfare.

Likewise, Barry Schneider (2002: 2-3) argues that the technological breakthroughs witnessed in recent years will also have profound implications on the strategic principles of war. Adding to Major-General JC Fuller's traditional principles of war, the author presents a revised set: Mass; Offensive; Surprise; Security; Command Unity; Objective; Maneuver; Economy of Force; Simplicityⁱ.

Albeit the importance accredited to technological change, the present RMA cannot be thoroughly understood unless it is examined in its wider perspective. It should be remembered that "technologies and systems enable but do not cause military revolutions" (J. McKittrick *et al*, 2002: 39). So it follows that the institutional, doctrinal and conceptual changes must also be added to the analysis so we can move beyond a simple revolution in military technology to a genuine Revolution in Military Affairs (A. Rodrigues, 2004: 78).

In his already classical text, *A Revolution in Warfare*, Eliot Cohen (1996), identifies four wider transformations in the military which he foresees will dictate and validate the future of the contemporary revolution:

- the forms of combat;
- the structure of military organizations;
- the nature of command;
- the power of States.

The great transformation in the forms of combat is revealed by the fundamental change in the relationship between the concepts of defense-offense, space-time, and fire-maneuver. Eliot Cohen demonstrates how new long-distance precision weapons, coupled with an unprecedented power of destruction, have dispersed present-day battlefields, making them more fluid. Nevertheless, the evolution of weapon systems, particularly their growing precision and destructive capabilities, may make it necessary to reassess the principles underlying the relationship between fire and maneuver. Furthermore the recent technological advancements, namely in the field of information technologies, also impel a new way of thinking about weapon platforms. As Eliot Cohen suggests the "platform has become less important, while the quality of what it carries – sensors, munitions, and electronics of all kinds – has become critical" (*idem*: 45).

The greater transfigurations of the RMA are expanded by their effect on the military institution, because "is not merely the tools of warfare but the organizations that wield them that make for revolutionary change in war" (*idem*: 46). Eliot Cohen (*idem*: 48) believes that after two centuries of mass armies made up of short-term recruits, future armed services will be mostly made up of long-term volunteers, incorporated into more integrated joint-forces. Consequently, the traditional distinctions between ground, naval, and air forces will eventually become diluted and more flexible resembling organizational models similar to present-day business corporations.

If somehow the organizational reforms are assumedly the most difficult to implement, the transformations in the nature of command seem simpler and more immediate. The need that the

military establishment has to adapt to the new technological setting makes the inclusion of new specialists mandatory. Actually, Eliot Cohen states that the great cultural challenge for the military organizations is to “maintain a warrior spirit and the intuitive understanding of war that goes with it, even when their leaders are not, in large parte, warriors themselves” (*idem*: 49). Thus far it seems that this transition is well underway since many armed forces in the West have already opened-up to the civilian sector in many areas. While not performing operational command functions, civil participation in traditionally military activities has resulted in a positive experience in bringing together these two distinct realitiesⁱⁱⁱ.

Finally, Eliot Cohen warns of the widening tendency for a dispersal of power. States are confronted with the paradox of seeing their power simultaneously reinforced and weakened. If the RMA offers incredible opportunities to states who can acquire modern equipments and systems it also provides them to other agents who can utilize them in unconventional ways. Therefore “to the extent that the revolution proceeds from forces in the civilian world, the potential will exist for new military powers to emerge extremely rapidly” (*idem*: 51).

Other studies of the contemporary RMA go still further in their analysis of the forces of transformation. Such is the case of military historian António José Telo (2002) who identifies an even larger group of innovative factors underlying today’s RMA:

1. A new concept of warfare;
2. A different relationship between the armed forces and society;
3. A greater understanding of information and its conversion into knowledge;
4. Space as the fourth dimension of war;
5. A new generation of weapons;
6. A vast revision of forces, operational concepts, and tactics.

Yet, without going into further detail, it is suffice to state that the transformations referred to above establish themselves and, at the same time, reflect the previsions of a wider makeover of the contemporary world. Consequently the opportunity to change and influence the sources of military power in order to tackle today’s new challenges has only been possible by taking advantage of the potential presented by the Information Age (D. Alberts & R. Hayes, 2003). The guiding principle behind the RMA is exactly the ability to harness the benefits of the Information Age, transforming military institutions into organizations tailored to the realities of its time.

Nonetheless, even though the current RMA has reached its maturity there is still a long way to go until it becomes an uncontested and complete certainty. It should be recalled that until the beginning of the third millennium very little had been done to change and adjust military force structures to the challenges ahead (D. Smith, C. Corbin, & D. Hellman, 2001). Until recently even the most advanced armed forces, including the United States, mirrored the conceptual logic of the Cold War Era. Therefore it can be said these forces still confirmed the organizational model of the Industrial Age, revealing all of its operational, conceptual, and doctrinal implications. Sustaining itself on a traditional practice of Command and Control (C²), the military reproduced Industrial Age principles: decomposition; specialization; hierarchy; optimization; deconfliction; centralized planning; decentralized execution (D. Alberts & R. Hayes, 2003: 37-48).

However the transformations witnessed in society in general are not compatible with the rigid and obsolete military establishments of the past. Present times incur new forms of warfare and new challenges to the security and defense of nation-states. Naturally, it is essential to adopt new policies which can better contribute to guarantee peoples security and consolidate a plural and democratic international order. In truth the options put forward for the future of the armed forces is "not to transform or not transform; the only real alternative is transform or expire" (A. J. Telo, 2006: 38).

The transformations required however must not confine themselves exclusively to the military establishment. Nation-states, with their monopoly over the legitimacy of the use of coercive force, have to start reforming themselves in light of this new security environment. Accordingly it is impossible to consider the security and defense issues of a nation without taking into account its

defense industry. Not only do they assume an important part in a States autonomous defense capability, but they also play a significant role in its overall economic and technological development.

An assortment of studies dispute to which extent the defense industry has contributed to overall technological progress and innovative activities. Many of them indicate a positive contribution by many defence industries to the growth of the regional and national economy. Even though the end of the Cold War greatly changed past assumptions, many States have undertaken the initiative to help restructure their national defense industry, assisting in their adjustment to the new security and defense realities. Nevertheless, in recent years there has mounted a growing debate over what role States should play in this process and what strategies are best suited to face the complex new challenges. In fact, the time-old "guns and butter" debate is once again on the political agenda.

II. Defense Industry Consolidation and Innovation

The larger and more developed western nations have been applying important reforms so that their defense industries can maintain themselves at the forefront of the modern-day transformation process. The imperatives underlying these industrial reforms come from the conviction that "most high-tech developments in the past few decades have been driven by the cold war's security imperative to maintain the technological edge" (A. Mallik, 2004: 3). Although the civilian contribution to technological innovation is unquestionable, the involvement of the defense sector should in no way be underestimated. Not only are

technological breakthroughs essential for dealing with new threats in the security environment, but military theoreticians are convinced that without a genuine venture in innovation there cannot be a sustainable RMA (B. Hagelin, 2004: 285).

Up till now it is possible to witness two distinct developments at work in the Western defense establishment. The US and Europe^{iv} have been at the forefront of the recent industrial consolidation process. The importance ascribed to these two regions comes from the fact that the major companies in the defense sector are American and European. In the

2007 “Top 100” report on the global defense industry, twenty-four out of the twenty-five highest ranking companies belong to one of these regions^v. Likewise, despite some recent developments in several Asian countries, it is also in the US and Europe that defense innovation process is more advanced, determining thus the future of the global defense industry.

Both regions are also committed to maintaining their superiority in this particular area, largely through generous investments in research and development (R&D). But regardless of similarities, the US and Europe reveal different methods, practices, and priorities regarding their defense industry and innovation processes. Table 1 exemplifies some of the most important differences.

	US	EUROPE
Defense and Homeland R&D Spending	67,5 billion dollars with prospects of further increases in coming years	Approximately 10 billion dollars expected to remain levelled (with some national exceptions)
Organization	Spending divided amongst <i>Military Services</i> leading to duplication of effort, competing priorities and inefficiencies	Spending divided amongst <i>national governments</i> leading to duplication of effort, competing priorities and inefficiencies
Funding Rules	Government funds whole cost of development and reimburses contractors for private R&D activities	Co-funding of R&D is typical
Civil-military Synergies	High level of government-university-industry interaction and some overlap between civil-military research effort (procurement reform designed to enhance these overlaps)	Fairly strict divide between civil and military research
Homeland Security R&D	Large and Active programme in DHS and NIAID	Limited effort outside EU preparatory action on defense security research

Table 1. Main Differences Between US and European Defense and Homeland Security R&D.
Source: A. James, 2004: 39

The distinctions in the defense R&D structure presented above reflect deeper differences in the way Americans and Europeans approach security and defense issues. For Nicole Gnesotto (2002: 4) the fundamental divergence relates to the question of conflict resolution, in which Europe supports mainly non-military means, contrary to the US. In a slightly different perspective, Robert Kagan (2002) suggests that the alteration in the distribution of power witnessed in the twentieth century

is the principal explanation for this distinction. In this sense Europe no longer has the power to determine contemporary military matters, seeking alternative strategies. However, both these points of view oversimplify the complex realities involved in the formation of today's intricate security and defense environment. A closer look at recent history might allow a better understanding of the present situation and permit a deeper insight into future prospects.

1. *The Establishment of the US Military-Industrial Complex*

The end of World War II witnessed the American rise to global preponderance. Initially inclined to play the role of financial hegemon, the US quickly realized it had to play a much more active part in world affairs. The commitments needed to face the impending challenges were enormous and diversified. Besides economic assistance, strategic commitments and political-military responsibilities were assumed on a global scale in order to guarantee the success of the desired liberal capitalist order. Consequently, according to Melvyn Leffler (2003: 498) US officials "came to believe that ever more weapons were necessary to support the risk-taking that inhered in co-opting the industrial core of Eurasia and in integrating its underdeveloped periphery".

The consequence of this new policy was a profound transformation in the configuration of the American defense budget and procurement system. Traditionally, US military budgets would increase only briefly during armed conflicts in which the country was directly involved. The end of those military clashes was followed by long periods of residual military investments. Moreover, civil contractors were solicited in the war effort, namely by increasing production and converting it to military use during the occasion of belligerence. Afterwards the contractors would return to their conventional commercial activities (M. Oden, 1999; H. Sapolsky & E. Gholz, 1999).

The Cold War deeply changed this state of affairs by initiating a long cycle of soaring defense budgets and altering profoundly the US defense structure. By taking responsibility for the leadership of the Western bloc, the US adopted a military-industrial strategy that relied on the incessant production of

state-of-the-art weapons systems. To face this challenge the different administrations fashioned large incentives and requirements for the arms manufacturers to maintain a high technological capacity. The US industrial milieu needed to adjust itself to the new organic and structural design motivated by military needs. According to Michael Oden adaptation to the new environment was a difficult test:

This core security strategy made demand highly unstable, technical requirements extremely demanding, with large economies of scale and long product cycles for builders of weapons platforms and other defense systems. To sustain a relatively stable group of firms committed to weapons research and production required a peculiar system of negotiated prices, contract allocation, dense and rigid product specification, and other regulatory practices.

(Michael Oden, 1999: 77)

The solution to these difficulties was found through the establishment of an agreement between the Department of Defense (DoD) and the prime contractors, in which the procurement cycles for the development of the main military systems were managed by way of a system of "prizes for innovation" (*idem: ibidem*). The major corporations would energetically compete in the design and development stages of new projects, supplying initial internal funding. The winner would then be awarded a sole-source contract by the DoD, assuring high profits on the companies production franchise. As a result of this process the major prime contractors could

warrant enough income to maintain research and production teams along with idle capacity. There was also an incentive for companies to assemble a large amount of R&D personnel in the hope of winning future prizes.

However, the operating costs ensuing from this corporate competition usually entailed the segregation of these activities from a company's commercial operations, leading to the creation of separate structures devoted primarily to the defense market. As a result, the Cold War witnessed the institutionalization of a large group of prime and subcontractors highly specialized in defense (*idem: ibidem*). Accordingly, this process led to a system in which the private sector came to dominate the US defense industry, making the Government "dependent on private contractors for most of the military-technical skills" needed for future warfare (H. Sapolsky & E. Gholz, 1999: 192). Whereas the State absorbed most of the financial risk, private enterprise profited and grew due to the hefty defense budgets which guaranteed long and stable production runs. A brief assessment of Cold War defense expenditures testifies to this situation^{vi}. For almost half a century, with exception for the years of the Korean and Vietnamese wars, the US upheld unprecedentedly high defense budgets without being directly involved in an armed conflict.

The end of the Cold War brought with it prospects of a "Peace Dividend". The hope for more socially oriented policies and reduction of national budget deficits, along with the firm conviction of Western military superiority impelled this outlook. Lacking a true threat to national security most Western countries trimmed down their defense expenditures without delay and condensed procurement. The defense market immediately felt the

aftershock, recognizing the need to restructure its industrial base (A. Markussen & S. Costigan, 1999; E. Pages, 1999; M. Intriligator, 1998).

Nonetheless, the US defense industry was not totally abandoned to the quirks of international market. A wide range of policies and political initiatives were developed to assist in this period of transformation (M. Oden, L. Wolf-Powers & A. Markusen, 2003: 16). Throughout the 1990s the different Administrations and several think tanks drew-up studies to deal with the restructuring of the national defense market.

Despite the studies different recommendations two distinct trends started to become visible at this time. The first major trend was the consolidation of the biggest companies in the defense segment. Even though there was an initial attempt by the larger corporations to try to integrate the commercial and military sectors of their activities, this endeavour did not last long^{vii}. The second big tendency was product diversification in many businesses, in particular the more modest size companies. Many companies were able to free themselves from the defense market and register positive turnovers in the commercial market.

The consolidation process, encouraged essentially by Wall Street banking activities and an inversion of the Pentagon's defense policy, led to the creation of four big defense manufacturers - *Boeing, Lockheed Martin, Raytheon and Northrop Grumman*. The detachment of their military and commercial divisions originated corporations highly oriented and dependent on defense activities. This course of consolidation had a profound impact on the American and international defense markets. The first great effect was the reduction of the number of US prime

contractors involved in the assorted defense segments. Next, coupled with the shrinking defense budgets, the competition and rivalry for foreign markets augmented considerably.

However, as stated before, the US Government played an important role in encouraging and guiding the consolidation of its defense market. The DoD was to a great extent responsible for inducing many corporate mergers and acquisitions. Its ultimate objective was to reduce political pressure for controlling defense expenditures while maintaining high levels of efficiency (E. Pages, 1999: 209).

Of the many courses of action taken by the DoD during the 1990s to assist the consolidation process it is worth conveying the three most significant (*idem*: 212-215): antitrust enforcement; subsidies for consolidation; and civilian-military integration.

For its part, the Clinton Administration was also responsible for catalyzing industrial consolidation, mainly due to its emphasis on rationalization measures. Trimming down defense expenditures and rationalizing industrial procedures was considered a benefit both for the Government and taxpayers. Following the adjustment of many antitrust policies the Administration created the *Defense Science Board Task Force* in order to delineate new orientations for regulating merger and acquisition processes in the defense market. In addition, financial assistance was granted to help the restructuring of businesses. In 1999 over 300 million dollars were awarded to the four main contractors (E. Pages, 1999: 214). Lastly, the Clinton Administration identified "dual use" technologies as fundamental to the consolidation process, launching several reforms in acquisition processes, such as

the *Technology Reinvestment Program*, in order to facilitate the acquisition of commercial goods and technologies by the defense sector.

Yet throughout the 1990's the US strategic doctrine continued to mirror the traditional Cold War premises. For instance, the 1996 *Quadrennial Defense Review* (QDR) indicated the need for the US to have means to conduct and be triumphant in two regional wars simultaneously. This outdated strategic concept did not contemplate the innovative realities of the contemporary world, such as participation in joint operations, the increase in international terrorism and weapons of mass destruction, the budgetary constraints of Western States, the growing importance of peace-keeping missions, and the materialization of the RMA (A. Markusen & S. Costigan, 1999: 15). The George W. Bush Administration recognized early on many of these contradictions and requested additional funding for defense, in particular for defense R&D.

Yet it was the events of 11 September 2001 that signalled a turning point in US defense policy. Straight away security and defense expenditures were augmented. In addition, American strategic concepts were modified to meet up to the new challenges, namely by the *National Strategy for Homeland Security* (July 2002), *National Security Strategy of the United States of America* (September 2002), and *Quadrennial Defense Review* (September 2001). This last document materialized the transition from a threat-based strategy to a capabilities-based one. Although the two-theatre scenario still persisted, a new emphasis was placed on the development of armed forces with a wide range of capabilities, capable of dealing with unpredictable future threats. It was imperative

to have a military able to adapt to multiple circumstances. The means idealized to tackle this new environment by the 2001 QDR was to invest in the development and application of new technologies in the armed forces. Only by having technological superiority is it possible to uphold the strategic advantage. Consequently, the 2001 QDR called for the enlargement of the funds necessary to achieve technological supremacy.

Even though previous studies had already called for a reorganization of the military establishment, the uniqueness of the new QDR was the importance it placed on the principles of the RMA as one of the main components of American strategy:

The ongoing revolution in military affairs could change the conduct of military operations. (...) For the United States, the revolution in military affairs holds the potential to confer enormous advantages and to extend the current period of US military superiority. Exploiting the revolution in military affairs requires not only technological innovation but also development of operational concepts, undertaking organizational adaptations, and training and experimentation to transform a country's military forces.

(United States Department of Defense, 2001: 6)

The details inherent in the transformation of American defense policy are not specified in detail in the 2001 QDR. But the document does commit the US to deeply altering its military structure. The transformations are naturally dependent not only on the armed forces, but society's innovative capabilities:

Today as well as in the foreseeable future, however, DoD will rely on the private sector to provide much of the leadership in developing new technologies. Thus, the department has embarked on an effort (a) to turn to private enterprise for new ways to move ideas from the laboratory to the operating forces, (b) to tap the results of innovations developed in the private sector, and (c) to blend government and private research where appropriate.

(United States Department of Defense, 2001: 41)

Nevertheless, the public sector has also played an important role financing and participating in the innovation process. The expenditures in defense R&D count for more than half the federal R&D budget. Analyses of the investments since 2001, as well as forecasts for upcoming years, seem to reinforce the conviction that "this nation can afford to spend what is needed to deter the adversaries of tomorrow and to underpin our prosperity" (*idem*: vi).

The various R&D activities are carried out by a wide range of institutions. Around 25% are federal laboratories mostly belonging to the DoD. There is also a large group of Research and Development Centers financed by the federal government which testify to the successful partnerships initiated during the Cold War. Yet the greatest share of R&D activities (66%) is due to private enterprise.

Funding regulations are highly complex and are the responsibility of the *Defense Federal Acquisition Regulation Supplement* (DFARS). Contrary though to the European system, the US Government usually funds the whole

Reassessing the "Guns and Butter" debate:
the role of military revolutions and defense industry
innovation in contemporary spatial development

costs of development, reimbursing private contractors for their R&D expenditures (A. James, 2004: 21). This practice was reiterated in 2001 by the Under Secretary of Defense for Acquisition and Technology:

Contractors should not be encouraged or required to supplement DoD operations by bearing a portion of defense contract costs, whether through use of their IR&D funds or profit dollars... One of the ways to ensure these companies remain financially sound is to consider carefully the degree of investment they are making in defense programs. In today's environment of reduced defense spending and fewer new start programs, it is short sighted to require contractor investment in defense research and development contracts. Instead we should permit contractors to earn a reasonable return on these contracts in exchange for good performance.

(Ap. Andrew James, 2004:21)

The public sectors active role in technological development is a political priority for the US Government. The ability to transfer technology from "federal R&D activities to the private sector is a formal part of all R&D agency missions" (A. James, 2004: 22). The Office of Technology Transition is responsible for transferring numerous DoD R&D activities to commercial markets. The final objective is to acquire technically superior defense systems at an affordable cost, which can be integrated into the national technology and industrial base (*idem: ibidem*).

The most important technology transfer mechanisms are the Cooperative Research

and Development Agreements (CRADA) and the Patent License Agreements. In the case of the CRADA, agreements between federal laboratories and external institutions are established to share the use of different resources in R&D projects of common interest. For its part the Patent License Agreements allow for the protection of intellectual property developed within the federally promoted institutions and its distribution to private companies.

However, a great deal of the innovation production and diffusion referred to is due to the work of the *Defense Advanced Research Projects Agency* (DARPA). This agency is responsible for the organization of the DoD's central R&D activities, namely by selecting and directing the high-risk and high-paying R&D projects. Created in 1958, DARPA's mission is to "maintain the technological superiority of the US military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use" (Ap. A. James, 2004: 23). Currently DARPA identifies seven areas as its "strategic thrusts": counter-terrorism; assured use of space; networked manned and unmanned systems; robust self-forming networks; detect, identify, track and destroy elusive surface targets; characterization of underground structures; and bio-revolution.

While throughout most of the Cold War by and large the most advanced technologies were developed by federal laboratories, universities, and government financed research centers, today's situation is significantly different. Contrary to the traditional conviction that investments

in the defense sector were the major catalysts of technological innovation (military “spin-offs”), in recent years there has been a growing endeavour to reap the benefits of commercial innovations. This has been made possible by the growth of technological developments in many fields, such as electronics, advanced computing, and medical research.

The DoD is confident that in near future a great deal of the technology incorporated into defense systems will have its source in commercial developments (“spin-ons”). In fact, it believes that “the ability of the United States to maintain its technological superiority will increasingly depend upon its ability to take advantage of technological advances in commercial industry” (A. James, 2004: 28-29). Some of the commercial key-technologies judged to play an important part in defense industry are Networking, Information and Communication Technologies, software and knowledge management systems, energy and power technologies, biotechnology, nanotechnology and robotics, and Artificial Intelligence.

The challenge ahead is to reform defense procurement rules and regulations to assist the technological transfer process. Traditionally

the Federal Acquisition Regulations has presented itself as too complex and inflexible, segregating defense contractors from the conventional economy. The DoD has made some recent efforts to surpass obstacles by creating the Grant and Cooperative Agreements, Technology Investment Agreements and the Dual Use Science and Technology Program. An additional incentive has been made by the Department of Homeland Security which has made the use of non-defensive technologies a priority.

Notwithstanding the need for further reforms towards the simplification of technological transfer between the military and commercial sectors, the US seems committed to maintaining their technological preponderance. The Congressional Budget Office (2003) estimates a rise in defense funds at least until 2020. The George W. Bush Administration’s Future Years Defense Program called for an annual defense budget of around 387 billion dollars until 2007. The programs continuation predicts a buildup until 2020, with an annual average of 428 billion dollars. The persistence of this trend leads the Congressional Budget Office to assert that it is possible that “defense resources could reach levels greater than those sustained during the Cold War” (2003: xiii).

2. Overcoming the European Quagmire

The state of affairs of the European defense industry and defense innovation system is substantially different from its American counterpart. The Cold War testified to the relegation of the European defense industry, along with its previous technological edge. While the European integration process of the last half century always attempted to deal

with the issues pertaining to the restructuring of the defense industry, most efforts were unrewarding^{viii}. Albeit the many concerns and efforts made by the various political agents, Europe has not been capable of creating a supranational organization which can help rationalize the division-of-labor between its different States. The end of the Cold War

Reassessing the "Guns and Butter" debate:
the role of military revolutions and defense industry
innovation in contemporary spatial development

confirmed a highly fragmented defense market, full of state-owned companies that were tailored to satisfy national security requirements.

Regardless of the countless reasons underlying this state of affairs, the end of the Cold War made it clear that the European defense industry had to adjust itself to the new security and defense environment. Various institutional transformations have been set in motion in recent years, especially since the late 1990's. Yet it is openly recognized that Europe's industrial restructuring is still wanting (European Union Institute for Security Studies, 2004).

Numerous obstacles can be identified to help explain the present situation. Certainly national budgetary constraints contribute to this state of affairs. So does the dispersal of investments that result from the lack of appropriate coordination at the Community level. However, the deficiencies in adopting and adjusting the defense segment to industrial and commercial innovations seem also pressing. Individually some states have begun transforming their armed forces. But, as a whole, Europe has not implemented the orienting principles inherent in the contemporary RMA (Group of Personalities in the field of Security Research, 2004).

As Gianluca Maspoli has declared, in Europe "the RMA has not been at the core of defence debates and armed forces transformation in the post-Cold War as it has in the United States" (2002: 6). This fact is distressing because it curtails Euro-American relations, increasing the operational gap between both regions. Fact is if Europe cannot accompany the American evolution in this aspect it risks becoming militarily

and politically inconsequential, losing any expectation of assuming a more decisive role in the most important decisions relating to international policy.

Regarding the defense industry in particular, this divergent pattern between the US and Europe will also be reinforced unless Europeans start regarding the significance of the present RMA. Thus, in a recent study conducted by the Group of Personalities in the field of Security Research (2004) European officials called for an expenditure of European investment in R&D equivalent to that of the US, as well as a redefinition of its military capabilities by means of an industrial conversion similar to the Americans.

The restructuring of the European defense industry has been underway for approximately a decade^x. It has revealed itself more sluggish than in the US, particularly due to a very complex setting made-up of assorted multinational regulations, legal requisites, and political motivations. Agreements between all the members of the European Union have not been an easy undertaking.

Consolidation has come about in recent years, resulting in the emergence of an industrial configuration dominated by four prime contractors, five to ten medium-scale corporations, and a wide range of smaller companies dedicated to particular niches in a variety of different segments (K. Vlachos-Dengler, 2004). The European defense industry consolidation process has, however, revealed itself far more atypical and complex than its American equivalent. Katia Vlachos-Dengler (2002 & 2004) suggests that there currently exists a European "spaghetti bowl" that can be characterized by ownership schemes organized by numerous intricate

cross-shareholdings, segment-and program-specific joint ventures, and other forms of cooperation agreements. At the heart of these complex interactions are the four prime contractors (BAE Systems, EADS, THALES, and Finmeccanica), which constitute the major players in European defense activities by participating in practically every relevant market segment.

The corporate development strategies outlined by the prime contractors has led them to implement different models of

consolidation, contributing in this way to the complexity of the European defense market (Table 2). Accordingly BAE Systems, THALES, EADS, and to a lesser extent Finmeccanica are active in most of the relevant defense segments of the European market: platforms (fixed-wing military aviation, helicopters, unmanned aerial vehicles [UAV], missile systems, ground systems, naval systems, and space systems) and subsystems (propulsion, defense electronics, electronic warfare, radars/sonars, and landing systems) (K. Vlachos-Dengler, 2002).

Company	Main Segments	Major Markets	Corporate Strategy
BAE SYSTEMS	Military aviation, UAVs, missiles, naval construction, radars and sonars, defense electronics	North America, Europe, Middle East	Looking to establish itself as one of the main manufacturers and system integrators in the global defense market, namely by reinforcing its activities in the US.
EADS	Commercial aviation, Military aviation, UAVs, missiles, helicopters, radars and sonars, defense electronics	Europe, North America, Asia	Concentration in the European market, transforming itself into the core actor in the EU civil aerospace business.
THALES	Defense electronics, missiles, radars and sonars	Europe, North America, Asia, Middle East, Asia-Pacific	Strategy based on the acquisition of a large number of small corporations and on a transatlantic joint venture. Although having the capacity to establish itself as one of the major system manufacturers, it has centered its principal activity on subsystems and defense electronics.
FINMECCANICA	Military aviation, defense electronics, aerospace, helicopters	Europe, North America	Looking to penetrate the leading defense projects and programs mainly by participating in the administration of numerous European joint ventures.

Table 2. Consolidation Models of the European Prime Contractors.
Source: L. Vinha, 2006

The future of the European defense industry will be greatly influenced by a series of driving forces directly affecting the defense market as a whole. The most important forces acknowledged are industrial consolidation,

company performance, European defense budgets, status of current and future programs, future trends in procurement, September 11 and its aftermath, and US and European regulation (Katia Vlachos-Dengler, 2004)

Reassessing the "Guns and Butter" debate:
the role of military revolutions and defense industry
innovation in contemporary spatial development

How these varied trends will develop will profoundly determine the future of the European defense industry. Their unpredictable evolution allow for much speculation about their future

consequences on the European defense market. However Katia Vlachos-Dengler (*idem*) sets forward three very consistent scenarios witch are illustrated in Table 3.

Driving Factors	Scenario 1	Scenario 2	Scenario 3
	<i>Market Forces Dominate</i>	<i>Muddling Through</i>	<i>Consolidation Reversal</i>
Consolidation	Extensive; accompanied by "cleaning up"; transatlantic tie-ups are live options	Slows down ("digestion phase"); portfolios are rounded off at the margins; transatlantic collaboration is limited to small acquisitions and specific joint ventures	Consolidation is reversed; Big Four spin off nonprofitable, noncore businesses; resulting companies are smaller, more focused, and more profitable; links with US companies are likely to be supplier relationships
Financial Strength	Performance improvement is driven by further scale and scope economies	Performance remains weaker than US peers; profitability is low	Performance is strongly improving, but under a different (smaller-scale) business model
Budgets and Spending	Flat or increasing budgets, more effectively spent	Flat or declining	Scenario robust
Programs	New programs successfully enter production based on larger risk capacity	Slow and erratic progress is made in most programs	Europeans switch to off-the-shelf purchasing of US designs
Procurement	Joint European procurement efforts revitalize market	Gradual progress; program by program	Scenario robust
September 11 and Aftermath	Commonality of interests between US and Europe is (re-) organized	Differences deepen between the US and Europe	Commonality of interests between Us and Europe is (re-) organized
Regulation	Reciprocal market opening for US and European markets	Limits on technology transfer	Relaxed US export licensing for European market; takeovers of US companies by Europeans are blocked

Table 3. Future Scenarios for the European Defense Industry.
Source: K. Vlachos-Dengler, 2004: 111

In the first scenario market forces prevail leading to an increase in corporate rivalry and subsequent deeper consolidation of European companies. The acknowledgment of common vital interests will eventually bring European and American companies closer together, encouraging new projects that will rationalize European procurement and reinvigorate its defense industry. In this setting, Europe would comprise only two “megaprimes” which would contribute to a deep restructuring of the industrial landscape, shrinking the competitive gap with the US.

The second scenario accounts for a muddling through, contributing to an extension of *ad hoc* initiatives, exacerbating the rift between US and European capabilities. This setting also comprehends the maintenance of reduced defense budgets and unarticulated cooperation between States. The end result would be an increase in the Atlantic gap through the warding-off of US corporations, especially in terms of technology, as well as a lack of long-term industrial sustainability.

The third and last scenario envisions an inversion of the consolidation process, allowing nonetheless for some companies to succeed in particular market segments. This is mainly due to the industrial fragmentation caused by low profits, leading to the discharge of less lucrative activities. The end result is a relatively large amount of smaller and more specialized companies. Yet this scenario is dependent on the definition of the European States defense budgets. If resources even out or are reduced the European defense industry will certainly wither and American companies will seize the European market. However, if investments do increase and if there is further industrial rationalization it is possible to prognosticate an increase in

specialized corporations with high turnovers. In this case, there will still be a great dependence on US companies to deliver the bigger defense systems.

The different scenarios pronounce very different possible futures for the European defense industry. However there is optimism about harnessing the opportunities already available. According to Björn Hagelin (2004: 294) Europe has a strong technological base capable of accompanying American potential. However, it is its inability to apply this skill to the military realm which has fostered the Atlantic rift. The European institutions recognize this situation and are looking to remedy it:

Europe must take advantage of its technological strengths. Technology itself cannot guarantee security, but security without the support of technology is impossible (...) To overcome these deficiencies, Europe needs to increase its funding and improve the coherence of its efforts. This implies (a) effective coordination between national and European research activities, (b) systematic analysis of security-related capability needs, from civil security to defence, (c) full exploitation of synergies between defence, security and civil research, (d) specific legal conditions and funding instruments for security-related research at the European level, and (e) institutional arrangements that are both efficient and flexible enough to combine Member State and Community efforts and to involve other interested partners.

(Group of Personalities in the field of Security Research, 2004: 6)

Recently the European Union created the European Defence Agency and established the European Security Research Programme to try to overcome some of the difficulties identified. For its part the European Defense Agency has four main functions: developing defense capabilities; promoting defense research and technology; promoting armaments cooperation; and creating a competitive European Defense Equipment Market and strengthening the European

Defense, Technological and Industrial Base. Similarly, the European Security Research Programme looks to take advantage of the duality of technologies and the growing overlap of security functions to bridge the gap between civil and defense research. By trying to coordinate research activities and by allocating substantial funding^x the European Union has committed itself to enhancing its defense industry technological capacity and competitiveness.

III. Catalysing Defense Innovation for Spatial Development

In the pages above it has been suggested that R&D and innovation in the defense sector play an important part in many countries National Innovation System (NIS). Although the benefits for the commercial segment of the advancements in the defense sector are still highly contested, examples such as the internet, GPS systems, and aeronautic and aerospace developments testify to successful transfers of military innovation to commercial markets. Recent studies demonstrate that the relationships between military and civilian agents and technology have been shifting considerably. Contrary to traditional industrial patterns, today advanced technology is being increasingly spun-in to defense applications and equipments. Official estimates are confident that the competition in the commercial sector will increase the pace at which technological innovations are incorporated into defense systems while diminishing their final costs. The fact that many of the transformations inherent in the contemporary RMA (networking, information and communication technologies, software and knowledge management technologies, energy technology,

biotechnology, nanotechnology, robotics, Artificial Intelligence, etc.) are developing significantly in the commercial sector reinforce this belief.

The repercussions of the transformation referred to above will reasonably have a geographical perspective. In a time-frame of about one to two decades the global defense industry will probably be much like Richard Bitzinger (2003: 69) forecasts:

- Smaller, as worldwide armaments production continues to decline and manufacturing capacity contracts, and as most second- and even some first-tier states abandon certain types of indigenous arms production;
- More concentrated, as armaments production is consolidated in the hands of a fewer and bigger companies and countries (both in the first- and second-tier arms-producing states);
- More integrated, as the globalization process gains momentum and as more armaments production is carried out transnationally - dominated and controlled by first-tier states.

This international setting requires a new international division-of-labor for the defense industry which greatly resembles a hub-and-spoke model (*idem*: 74). It is already possible to detect this spatial organization in which the smaller countries defense industries occupy a sub-alternate position. While the prime contractors, located primarily in the largest Western nations, develop the more knowledge-demanding activities, the second-tier countries companies will constitute themselves as suppliers of less technologically-demanding products, especially in specific industrial niches, primarily through subcontracts, partnerships, joint ventures, and external acquisitions.

Surely some countries will try to maintain a greater autonomous industrial capacity for their defense industries, despite the likely costs inherent in redundant activities (for example, China, Russia, India, Israel, etc.). Nevertheless, in the Western liberal economies the hub-and-spoke model seems to be the most plausible scenario, especially when considering participation in wider institutional settings such as the UN, NATO, and EU.

Understandably national policies should reflect this changing reality. There is no reason for the different countries not to profit from the potentialities offered in the new security and defense environment. The development of policies relating to national defense industries should be modeled into a wider national industrial policy. Some countries have been pursuing this track for many years. In some cases, defense industry clusters, in countries such as the USA or Australia, have a more concentrated spatial dimension, namely at the local or regional level. In other cases, the impact is nation wide, as is the case in Israel. Still, some countries have involved

their defense industries in system-specific clusters, as is the case in Polish naval construction and repair.

Given the emphasis in recent years ascribed to the importance of the geographic context in innovation processes, governments should look to take advantage of the new defense market requirements in their local development strategies. In this sense, contemporary globalization “simply compels firms and governments alike to focus on the remaining localized (immobile) capabilities; the ones that have not yet become *ubiquitous*, equally available to firms regardless of their location” (B. Lundvall & P. Maskell, 2003: 364).

Isabel Marques and José Félix Ribeiro (2003: 12) identify the spatially fixed attributes that will continue to strategically determine local and regional competitiveness:

- Existence of a considerable workforce made up of highly qualified and diversified personnel which is capable of developing and reproducing those activities most associated with the knowledge production, along with the presence of education and research establishments that can replenish the labor force and help it adapt quickly to the evolutions in technology and the market;
- Accumulation of complementary activities that can create a more solid skill-base, capable of adapting to new technological and market trends;
- Presence of formal and informal channels for the transmission of technologically-based or organizational innovations and the accumulation of knowledge about regional or segment specific markets and the best way to incorporate into international exchange networks.

The places that can articulate these means successfully will emerge as the new "strategic spaces" (*idem: ibidem*). They will be capable of generating new competitive advantages, despite the mobile nature of innovational resources, because economic growth is increasingly based on intangible resources resulting from complex geographic processes. Therefore, spatiality assumes itself as an active agent in innovation and knowledge-creation. Governments and the vibrant local and regional agents should look to harness

their local capabilities and resources to face this test.

Various approaches can be applied. Whether through clustering policies, development of dual-use technologies, industrial offsetting, or other means, governments – especially at the regional and local scale – ought to be capable of adapting their local resources to tap into the potential offered by the profound transformations in the global defense and security environment.

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ⁱ Michael O'Hanlon identifies four main schools of thought about the contemporary RMA: System of Systems; Dominant Battlespace Knowledge; Global Reach, Global Power; and Vulnerability.

ⁱⁱ According to Barry Schneider, General Fuller cited seven principles of war: Objective, Offensive, Mass, Economy of Force, Surprise, Security, and Cooperation. Later, the US military dropped Cooperation as a principle of war and substituted Simplicity and Command Unity.

ⁱⁱⁱ For examples of some services and functions in which the civil sector has been active in the military realm see Alexandre Rodrigues (2004).

^{iv} When referring to Europe throughout this article it is meant to comprehend only to the countries belonging to the European Union.

^v The only company in the first 25 not located in the US or Europe is Japan's Mitsubishi Heavy Industries, ranked 25th. Out of the Top 100 ranking, only 30 companies are not American or European (<http://www.defensenews.com>).

^{vi} For a brief review of US defense expenditures throughout the Cold War see Luis Vinha (2007).

^{vii} There were some cases of success in this endeavour, namely with companies such as *TRW*, *Raytheon*, *Rockwell* and *Hughes*, which were able to transfer knowledge and know-how from their spatial and defense electronics fields to commercial satellites and telecommunications and automotive fields.

^{viii} For a more detailed description of the evolution of the European defense industry during the Cold War see Luís Vinha (2007).

^{ix} For a thorough and detailed understanding of the consolidation of the European defense market see Katia Vlachos-Dengler (2002 & 2004).

^x In the Group of Personalities for Security Research report of entitled "Research for a Secure Europe" it is called for at least € 1 billion per year to be provided for security-related research within the EU's Framework Research budget, starting in 2007.