Global perspectives on the European arms industries

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Abstract

The authors of this article offer perspectives on the symposium on the European arms industries published in volume 12, number 1 of *The Economics of Peace and Security Journal*. The symposium contributions cover the history, current situation, and likely future prospects of the European naval, land armaments, military helicopter, aerospace, and outer space industries. The perspectives then comment on the articles as a group and do so from a global vantage point inasmuch as the commentators constitute a group of prominent researchers and policy analysts drawn from around the world.

The authors of the symposium on the European arms (and space) industries published in this issue of *The Economics of Peace and Security Journal* all work in the Francophone context, specifically in Belgium and in France. This is by happenstance but raised the question of how scholars residing in different regions of the world might view the five articles in the symposium. The editors thus invited prominent researchers and policy analysts from around the world to each contribute a "perspective" of about 1,000 words in length.

–The Editors

RICHARD BITZINGER

Perspective: The European Defense Industry's Never-Ending Death Spiral

A certain melancholy descended over me as I read the articles in the symposium on the European arms industries in this issue of the journal. All are fine works and excellent analyses, yes, but the themes and arguments were painfully familiar.

Do not blame the authors. Four articles provided excellent discussions of recent trends and developments in four key sectors of the European defense technology and industrial base (EDTIB): naval shipbuilding (Bellais), military helicopters (Droff), land armaments (Caralp), and space (Zervos).

The fault, if there is one, lies more in the nature of the European defense industry itself, which has been in a state of perpetual crisis—a never-ending death spiral, as it were—for several decades. The problems and challenges facing European arms manufacturers, as laid out in these articles, were as familiar 10, 20, or 30 years ago as they are today.

To be sure, many of the authors describe an apparently thriving European defense sector. For naval shipbuilding, armored vehicles, and helicopters, business is booming—for now. But these articles also strongly insinuate that the current business model is unsustainable over the long run. As such, the European defense industry faces an uncertain future.

If anything, the problem today is likely worse than it was 15 or 20 years ago. In the 1990s and early 2000s, the Europeans were awash in new defense projects, including three different types of combat aircraft (the Rafale, Eurofighter Typhoon, and Gripen), two heavy-lift utility helicopters (the EH-101 and the NH-90), a transport aircraft (the A-400M), and several missile programs. Today, however, the European defense industry faces a more fragile future. While factories are currently humming, there is a dearth of new defense projects in the works. (Josselin Droff notes, for instance, the lack of new helicopter programs.) At the same time, defense innovation is languishing. European spending on defense R&D has fallen by

around 20 percent over the past decade, while spending on basic research—the "seed corn" of future production—has dropped by nearly one-third. Moreover, much of the EDTIB, as in the case of shipbuilding and armored vehicles, remains highly fragmented along national lines. Barely nine percent of EU defense R&D is currently allocated to collaborative programs, resulting in duplicative, competing programs.[1]

If the challenges facing the European defense industry are well-known and long-standing, so too are the solutions often put forth: further consolidation and rationalization, expanded intra-European and transatlantic arms collaboration (including transnational mergers, acquisitions, and joint ventures), the promotion of arms exports, and the expanded spin-in of commercially sourced dual-use technologies. In fact, all of these schemes were attempted during the 1990s, but by the early 2000s most of them had run out of steam. Particularly when it came to cross-border tie-ups, the process seemed to reverse itself in cases (as Renaud Bellais points out for the case of ThyssenKrupp's divestiture of Kockums).

It is easy to be cynical, therefore, of initiatives that were already attempted and which turned out to be so dissatisfying. At the same time, the stakes are too high not to do anything. Unless Europe can find a way out of its troubles, it runs the risk that, over the next two or three decades, the EDTIB could lose its high ranking within the global hierarchy of arms producers. Take just one example, advanced combat aircraft: Europe has not initiated a new jet fighter development program in over 30 years; there is simply no money to fund a fifth- or sixth-generation combat aircraft. Except for retrofits and upgrades, by 2030 Europe could consequently be out of the fighter jet business altogether. Asia, meanwhile, has six new combat aircraft in development: the Chinese J-20 and J-31, the Japanese X-2, the Korean KF-X, and India's Advanced Medium Combat Aircraft (AMCA) and Fifth Generation Fighter Aircraft (FGFA, a collaborative project with Russia).

In the fifth article in the symposium, Renaud Bellais and Daniel Fiott offer a new approach, one that takes a page from the United States' third offsets strategy that seeks to leverage "disruptive innovation" in advanced (and mostly commercial) technology sectors such as autonomous systems and robotics, nanotechnologies, big data, and additive manufacturing. As they put it, the EDTIB "can no longer operate in a vacuum whereby it develops capabilities with limited interaction with the rest of the economy ... the industry has to look for technological inputs from outside the DTIB to focus on combinatory innovations rather than on traditional defense-technology driven ones."

This initiative has its own problems, however. In the first place, "disruptive innovation" has come under considerable criticism lately, both as an idea and as industrial policy. In addition, leveraging commercial dual-use technologies has been tried before, and with little to show for its efforts.[2]

All this, of course, is not to argue that it is fruitless to try to reform the European defense industry. At the same time, however, one should recognize that many of the ideas being put forth to restructure, revitalize, and reorient the EDTIB are not particularly novel. *Plus ça change, plus c'est la même chose*—and don't get your hopes up.

AUDE FLEURANT AND YANNICK QUÉAU

Perspective: Challenges and constraints faced by the European arms industry

Since the early 2010s, a growing sentiment among observers of the military-political economy of the United States and of Western Europe is that the arms industries of these countries are on the verge of entering, or perhaps already are in the midst of, a new transformation phase. This perception comes from a variety of factors that shape both state demand and industry behavior such as changing geopolitical conditions, defense budget resource limitations (especially for procurement and research and development), and the interest shown by military institutions in emerging and disruptive technologies developed by the civilian sector for military applications which, in turn, pose challenges to states' capacity to control their dissemination and their uses.[3]

The current situation of the West-European arms industry appears to be a direct continuation of important transformations that have been ongoing since at least the 1970s and 1980s, driven by both economic and political pressures. Privatization of publicly owned companies and state arsenals was followed by large, nationally-based combinations of arms producers, creating larger entities concentrating more capabilities within a single segment. The massive process of mergers and acquisitions that first took place in the 1990s in the United States then drove an agenda of greater supply-side cooperation and integration in Europe in the late 1990s and early 2000s as well. The intent was to support and upgrade first-tier, complex weapons systems production and integration capabilities under European control, which meant amalgamating the resources of the large arms-producing countries.

By examining the current situation of specific production segments, four of the articles in the symposium on the European arms industry in this issue of the journal highlight that despite major changes that have occurred since the 2000s, European arms producers and their respective national ministries of defense have not resolved enduring issues and tensions associated with the outcomes of decisions made in earlier periods. Renaud Bellais' paper on the European naval

industry underlines shortcomings of the European defense integration project that was at the top of the agenda for the larger arms producing countries. It also exposes tensions between economic constraints and the desire to maintain broad national control over arms production capabilities, an uncomfortable dilemma that is also present in other military production sectors. Adrien Caralp's examination of the European land armaments industry also comes to the conclusion of excessive production capacity for that segment, but he cites different reasons for this capacity surplus. Whereas naval production overcapacity is linked to states' ability to maintain autonomy of supply, land systems duplication is attributed to lower barriers of entry, combined with growth in demand in Europe during the 2000s. Both authors agree, however, that it is difficult to determine whether this overcapacity is sustainable in the longer term.

The military helicopter case study presented by Josselin Droff emphasizes long-standing, structural issues which the European arms industry as well as the defense ministries have been facing on a recurring basis, notably the absence of new, sizeable national modernization programs, and the inherent difficulties associated with large cooperation programs such as the N-90 helicopter. The industry has few options. Droff suggests that, besides modernization and cooperation, turning attention to more versatile and dual-use platforms could support the military helicopter industry. Vasilis Zervos' article on the European space industry provides an overview of an inherently dual-use (civilian-military) and opaque sector. Considered by large military powers to be an essential and, in some instances, highly sensitive component of their defense and security arsenals, space-related systems often are labeled force multipliers or enablers of modern military forces. However, the importance of civilian activities in space has given this industry a very different profile than those observed in other military production segments. Finally, Renaud Bellais and Daniel Fiott explore the possibility of a paradigmatic change in how the arms industry could be transformed (or transform itself) by leveraging civilian innovation capabilities and by combining forces to develop new, disruptive capabilities.

The detailed examinations of specific arms production sectors in Europe presented in this set of symposium articles provide valuable, facts-based descriptions and analyses of current trends and potential future evolutions as well as suggest alternative ways to address some of the challenges that these industries face now and in the future. They stress some of the major consequences of the constraints with which the industrial actors have been dealing, such as the need to export to make up for insufficient domestic demand. As is often the case, however, they also leave some concomitant issues in the dark. Notably, a closer examination of demand-side drivers would seem warranted—especially in the current geopolitical environment where increased threat perceptions and interstate tensions in several parts of the world, including Europe, may affect military expenditure and weapons requirements. Similarly, from the supply side, the internationalization of the European arms industry through major export contracts and associated offsets, which has led some European companies to establish a long-term production presence in recipient countries, raises questions about how this internationalization process would or could interfere with any European integration project. Finally, it would be interesting to compare the current U.S. push for a rapprochement between military and civilian producers to a similar attempt made in the 1990s in the context of the Revolution in Military Affairs.

KEITH HARTLEY

Perspective: An Economist's View

The five articles in the symposium deal with important and under-researched aspects of the European defense market, namely, the military helicopter industry, naval shipbuilding, land armaments, the space industry, and the impact of innovation on the defense market. These are sectors which continue to be characterized by fragmented national markets, the remaining scope for industrial restructuring, the challenges of maintaining a future industrial capability, and the need for defense firms to adjust to change. In contrast, the European aerospace industry has achieved substantial restructuring and progress in arms collaboration (e.g., collaborations in Typhoon, the A-400M airlifter, and missiles).

Typically, economists address the issues around the European defense market by asking what is the problem, why does it arise, and what are the policy solutions?

The policy problem

Problems arise because national defense budgets have to fund the acquisition of increasingly costly defense equipment and military personnel. Equipment costs often rise at rates of up to 10 percent per year for combat aircraft and at rates of four to six percent per year for tanks and warships. These rates usually exceed the growth rates for military expenditure, leading to long-run reductions in quantities bought. Already thirty years ago, commentators forecast a future of a single-ship navy, a single-tank army, and a single "Starship Enterprise" for the air force.[4]

In addition to economic pressures on military budgets, new technology means that defense contractors have to adjust to change. The long-run trend is toward the creation of a smaller

number of larger arms firms involved in supplying a range of traditional and new arms markets (e.g., cyber- and security markets). However, European nations continue to prefer supporting their national arms industries and their national champions: They prefer and are willing to pay the price of independence. As a result, within Europe, there remains substantial duplication of military R&D and relatively small production runs failing to exploit economies of scale and learning. These features arise in European land armaments and naval shipbuilding industries.

Why is there a problem?

Two features are dominant, namely, rising unit equipment costs and support for a national defense industrial base. Rising costs reflect military pressure for high-technology equipment where the armed forces demand equipment which is technically superior to that of its potential enemies (a tournament good). Rising costs also affect the military personnel required for an all-volunteer force.

Economists predict that rising unit costs will lead to incentives to substitute cheaper factor inputs for costlier ones. For example, costly combat aircraft might be replaced by cheaper missiles, tanks replaced by attack helicopters, and naval frigates replaced by maritime patrol aircraft and unmanned aerial vehicles (UAVs). Similarly, costly soldiers might be replaced by cheaper reserves and civilians (e.g., private contractors). Such substitutions might have implications for the traditional monopoly property rights of each of the armed forces when, for example, land-based aircraft and UAVs replace naval frigates for anti-submarine roles and air forces are being replaced by armies and navies.

The problem also arises from European nations (and others) being willing to pay the price of an independent national arms industry. For aerospace, European nations have sacrificed some independence through their support for collaborative programs with one of the most successful collaborations in the civilian aircraft Airbus. Even here, though, the Airbus management of the collaborative A-400M airlifter has been much less successful.

The willingness of European nations to collaborate on military aerospace programs reflects their costly R&D and the economic benefits of pooling national production orders. European collaborations have been less prevalent in land and sea systems. This probably reflects the relatively lower R&D costs of these systems compared with aerospace projects and the fact that national orders allow some economies of scale and learning so that independence is not too costly. Independence is also sustainable where arms firms obtain export orders, so increasing their national output. Also, shipyards are often located in high unemployment areas so there are political gains from awarding naval contracts to such regions. State ownership of arms firms will reinforce nationalism.[5]

A further feature of arms markets also explains the preference for nationalism. Governments are central to arms markets. They are major buyers of arms (sometimes the only buyer) and they can use their buying power to determine the size, structure, performance, and ownership of national arms industries. Public choice analysis predicts that government choices will be influenced by politicians with their pursuit of votes, by bureaucracies (armed forces) in pursuit of larger budgets, and producer groups (arms firms) seeking incomes and profits from arms contracts.[6]

The solutions

A range of policy solutions exists, each with different benefits and costs. Examples include more industrial restructuring involving national and international mergers both within and between European arms firms and between European and U.S. firms. Again, such restructuring will be constrained by the preferences of national governments. Or, national defense markets can be extended through more military outsourcing allowing arms firms to bid for work traditionally undertaken in-house by the armed forces (e.g., military helicopters).

There are challenges for European arms industries. New technology could mean that the center of gravity in defense R&D is shifting away from traditional defense firms to new commercial firms. This raises questions about the ability of defense firms to adjust to change and whether the defense firm has a future. If so, what might the future defense firm look like? While the future is characterized by uncertainty, it is likely that the future defense firm will be radically different, just as today's arms firms are completely different from those of the year 1900. Outer space offers future possibilities for new markets and opportunities for new entrants (e.g., a Star Wars future?).

Europe has a further challenge. Maintaining national defense industries is not confined to buying from them. They have to be retained during periods when there are gaps in development and production work (e.g., helicopters). Key labor skills and specialist production facilities will need to be retained for future orders. Retaining such assets is not cheap. Alternatively, releasing resources when contracts end requires substantial costs to be incurred when recreating such specialist assets.

Economics offers a solution. The economic principles of competition and trade based on comparative advantage could be applied to Europe's armed forces and its arms industries. The result would be armed forces and arms industries

specializing by comparative advantage with arms contracts allocated on the basis of competition. But such solutions would require trust among nations through their participation in a military alliance or membership of a political union. There remain major political constraints on an economically efficient European defense market.

WILLIAM HARTUNG

Perspective: Comparative prospects for the European and U.S. defense industries

The five articles in the symposium on the European arms industry in this issue of the journal stress a number of common themes affecting the key military-industrial sectors in Europe, including shipbuilding, land armaments, and the helicopter industry. Important factors that bear on the future of these industries include relatively tight defense budgets and resistance to industry consolidation rooted in issues of national sovereignty and economic concerns. Each of these, and other, factors undermines the current approach of a fairly fragmented industry relative to available market opportunities.

Potential counter-balancing forces include the possibility of consolidation (despite a history of failed or partially failed initiatives), continued or increased reliance on export markets, expansion of civilian and dual-use lines of business, and a focus on maintenance and after-service opportunities, which over time can match or exceed the size of the market for initial procurement. Another wild card will be the extent to which European defense budgets increase due to new challenges emanating from Russia, and whether increases in spending by East and Central European countries like Poland and Hungary will lead to new sales by Western European firms.

Similar forces are at play in the U.S. defense industry, but they are less severe due to the sheer size of the U.S. market. Despite the slight dip in the Pentagon's main budget that resulted from budget caps imposed by the Budget Control Act of 2011, the roughly USD600 billion per year of U.S. military spending remains at historically high levels—higher, adjusted for inflation, than at the peak of the Reagan buildup of the 1980s, and larger than the military budgets of the next seven countries in the world combined. Roughly one-third of this USD600 billion total is devoted to weapons procurement and R&D.[7]

To give just one indicator of the relative scale of U.S. and European spending, the new Trump administration's proposed USD54 billion military expenditure *in*crease alone, for fiscal year 2018 (October 2017 to September 2018), is roughly equal to the entire military budget of the United Kingdom, and slightly larger than the military budgets of France or Germany. The advantage of U.S. defense firms is further underscored by U.S. dominance of the global arms market. From 2009 to 2015—the bulk of President Barack Obama's two terms in office—the Pentagon brokered nearly USD300 billion in new arms offers to foreign clients for U.S. firms under the Pentagon's Foreign Military Sales (FMS) program. This is a larger figure, adjusted for inflation, than any U.S. administration since the second world war. Not all of these offers will result in final sales, and a significant portion of the value of each deal is for support services and training rather than weapons procurement, but exports represent a potential bright spot for the top U.S. defense firms such as Lockheed Martin, Boeing, Northrop Grumman, Raytheon, and General Dynamics. This is particularly true because deals concluded now will take years to complete, potentially resulting in a steady flow of contracts to U.S. arms makers for the next five years or more, independently of how many new orders are placed in that time frame. For example, a Saudi order for over 70 Boeing F-15S aircraft was first put on offer in 2010 and resulted in its first delivery of a finished aircraft in December 2016.[8]

Another factor likely to lock in significant sales for U.S. firms for the longer term is the F-35 program, which includes European partners in Denmark, Italy, Norway, Turkey, and the United Kingdom, as well as partnerships with Australia and Canada. Other deals concluded or in the works include F-35 sales to Israel, Japan, and South Korea. The F-35 program has been plagued by cost and performance problems, but so far the Pentagon is staying the course with production rates at about three dozen aircraft per year. Although well below the 100 or more aircraft per year originally projected at this point in the program, if the experience with recent U.S. aircraft programs like the F-22 and B-2 are any guide, the ultimate number of F-35s purchased by the United States could end up being perhaps half as many as the 2,400-plus currently planned. But even at these reduced levels, the F-35 will be a boon to the U.S. industry for the next two decades, particularly for prime contractor Lockheed Martin and major partners like Northrop Grumman. The impact will spill over to the European industry via shared production, with a particularly strong role for BAE Systems due to the U.K.'s role as the primary U.S. partner in the F-35 program. The pattern of F-35 sales will make U.S.-European competition for military aircraft sales in markets such as the Middle East and South Asia (primarily India), where the F-35 is unlikely to be sold, all the more fierce in the coming decade or more.[9]

As for the U.S. shipbuilding sector, the Trump administration's pledge to begin the process of building the U.S. Navy up from its current level of 272 to 350 combat ships will make exports—which have never been a major factor for

the U.S. shipbuilding industry—even less important for the foreseeable future. Armored vehicle production also is likely to receive a boost from the Trump buildup, given his pledge to add hundreds of thousands of personnel to the Army and Marines, especially since tanks and light vehicles are produced in the key electoral states of Ohio, Michigan, and Wisconsin—states that were pivotal in Donald Trump's victory in the 2016 presidential race. Trump already has suggested that he will help areas that helped him, and doing so in the sphere of military procurement is hardly a new phenomenon.[10]

The space sector of the U.S. defense/aerospace complex is poised for a more significant transformation than other sectors of the U.S. arms production industry. This is due to the introduction of competition into the space launch business, with Space-X challenging Boeing and Lockheed Martin, which until recently had a monopoly on U.S. military satellite launches via a joint venture known as the United Launch Alliance. The novel element of the competition is that Space-X, owned by entrepreneur Elon Musk, produced its launch vehicle without U.S. government R&D or production funding. The introduction of new players into the space sector may pose short-term risks, such as when a Space-X rocket crashed in a recent launch effort, but for the longer-term competition in this growing field could yield benefits in both price and innovation.[11]

An important caveat to all of this is, of course, that the Trump administration's proposed budget is likely to be substantially altered as it works its way through Congress, with concerns about the federal government budget deficit and opposition to deep cuts in spending on diplomacy and domestic programs serving as possible curbs on the kinds of Pentagon-related spending increases the Trump administration is seeking. Moreover, some major U.S. arms clients, like Saudi Arabia, seem to have put some big deals on the back burner for now, suggesting that some of them may fail to materialize, undercutting the export revenues of key U.S. firms.

STEFAN MARKOWSKI AND ROBERT WYLIE

Perspective: Military innovation and military industrial capabilities

In the concluding article of the symposium on the European arms industry in this issue of the journal, Renaud Bellais and Daniel Fiott argue "that the global defense industry is shifting toward *a new paradigm* in which an emphasis on technology-driven capability development is being undermined by disruptive innovations emanating from the commercial sector" (our emphasis). The previous paradigm was essentially that of the cold war era, characterized by "a technological arms race in which arms-producing countries invested heavily in [military-specific] R&D to achieve dominance [based on] technologies with incredible military potential." Now, with "the advent of disruptive technologies emanating from the commercial sector" the military-industrial actors face the three-pronged challenge of how to: (a) "integrate disruptive technologies into existing or planned capabilities"; (b) "adjust organizational behavior to capture commercially-driven innovation"; and (c) "foster viable relations between the military establishment and commercial firms and their civilian research clusters." In this comment we review this proposition having regard to the other symposium contributions as well as to wider considerations.

For much of the cold war era the imperatives of nuclear retaliation, as reflected in the doctrine of Mutually Assured Destruction (MAD), made both cold war superpowers accept that no degree of technological superiority made a third world war a winnable proposition. Thus, as Bellais and Fiott suggest, the two superpowers and their respective allies invested heavily in military research and technology (R&T) to produce strings of technology demonstrators including, for example, then-U.S. President Ronald Reagan's Star Wars challenge in the 1980s. Had these demonstrators been developed further, and had they been deployed and allowed to mature, they could have disrupted the military and industrial capabilities of the two military blocs much more than has in fact been the case. Instead, acceptance of the MAD doctrine fostered at least a tacit realization that any significant military advantage achieved in arms conflict with weapons of mass destruction (WMD) between the two superpowers would have triggered a globally catastrophic nuclear devastation. Paradoxically then, the cold war era was a period of restraint where non-WMD capabilities of the two dominant military blocs were deployed in a relatively limited way on the fringes of their respective spheres of influence (e.g., in Viet Nam and Afghanistan). In this strategically stable environment, the prudent defense tactic for both military blocs was to engage in a technological know-how race but not in an actual arms race. Military platforms were built for adaptation and endurance, and industry capabilities were formed to support long runs of equipment production and through-life development and adaptation. In this relatively stable strategic and non-adventurous political environment evolved what Bellais and Fiott call, with reference to James Kurth, "the flow-on principle," based on "a tacit agreement between the military and defense companies" that "leads companies to promote the renewal of existing systems that are based on assets, technology, and know-how they already master."

This relatively permissive environment allowed Western Europe to develop national variants of platforms and systems

within the trajectories of non-WMD technologies established by cold war imperatives. This also allowed Western Europe to experiment with various models of international technological collaboration and with various mixes of public and private investment.

However, the post-cold war world is strategically far less benign. In today's multipolar environment, the nuclear capabilities are still in place, but there are many more fingers on the nuclear triggers and the powers of deterrence are far less effective than before. New, aspiring regional powers, such as China, Iran, and the Russian Federation, are essentially old imperial countries that seek their own spheres of dominance, often in regions which they have dominated in the past. This challenges the United States as the world's sole superpower. In response, the U.S. has continued to invest in military-specific R&T, such as space-based weapons systems, directed energy weapons, and high-velocity interceptor technologies. None of these could be fashioned in the civilian domain, even if they incorporate many elements of civilian high-tech knowledge. The competition among states for military advantage will ensure that these technologies are highly classified by national governments and will only be developed and produced in dedicated facilities that satisfy governments' stringent industrial security requirements. The same imperatives will lead the U.S. and other governments to protect their technological advantage by continuing to intervene in the market for such technologies and control, or at least delay, their diffusion.

This is not much different from the old cold war era except that there is much less confidence that the "new cold war" adversaries, such as the Russian Federation, Iran, or even China, are able to restrain their military hawks and mitigate their appetite for regional conflicts. And this means that the old cold war scenario, whereby each aspiring imperial power limited its sphere of influence and stopped contesting the status quo, was the best-case scenario. Containing the arms race, they could stabilize investments in military and military-industrial capabilities. In contrast, the new cold war scenario is that of the U.S. continuing to invest in massive surveillance, first strike, and retaliatory capabilities, which would keep its mainland safe even as their use would have devastating direct and collateral effects in other parts of the world. Rather than looking to the commercial sector to generate the new and inherently disruptive technologies required to prevail in this fluid strategic environment, we believe it likely that U.S. capability managers will continue to foster a U.S. military technological innovation system that is based on a dynamic symbiosis of both public and commercial investment. At any point in time, the technological product of this symbiosis—and the balance of commercial and public investment involved—will be shaped by the specific nature of the perceived threat or security challenges demanding a response. This leads us to suggest that, for the United States at least, Kurth's flow-on principle needs more nuanced treatment. Moreover, the U.S. government's enduring incentive to control the diffusion of military-related technology, irrespective of its public or commercial origins, suggest that, despite the political and economic impediments, European governments will have a commensurately strong incentive to continue searching for pan-European solutions to requirements for novel military capabilities.

Another major change from the old cold war era concerns the proliferation of asymmetric conflicts, many with religious overtones, in which asymmetric adversaries are highly tolerant of civilian and combat casualties. They are adept at using low-tech know-how to weaponize civilian technologies although, in some areas they may also use high-tech know-how to weaponize high-tech civilian information technology and telecommunication assets (e.g., cyberspace). This is the area where the civilian sector has knowledge and resources which the military could usefully tap to acquire radical, disruptive technologies and where the new technological paradigm described by Bellais and Fiott may partially apply. Clearly, the military are keen to scan civilian know-how in all areas of potential military applicability, especially those where currently open conflicts necessitate military and political responses, even as it recognizes limits to the degree to which it can rely on civilian technology suppliers in areas such as signals intelligence that really matter for military advantage in the field. While more potentially disruptive technologies may be acquired from civilian sources in years t come, they will be refracted through military-specific R&D facilities and will be militarized. This, especially in the western-style democracies, is a long way from day-to-day civilian business. For as long as defense remains a public good, national governments and the citizens that elect them are likely to demand some measure of security and accountability over the development and application of such technologies for military purposes, whether originated in the defense or the civilian-commercial sectors.

Notes

1. Dropped by nearly a third and barely nine percent: European Defense Agency (2014, p. 5).

2. Considerable criticism: Lepore (2014).

3. Military-political economy: When assessed in terms of arms sales, the largest arms companies as well as those that provide the most sophisticated weapon systems and technologies are, in their vast majority, based in mature military-industrial countries such as the France, Germany, Italy, the United

Kingdom, and the United States. See https://www.sipri.org/databases/armsindustry.

4. Commentators: See, e.g., Kirkpatrick and Pugh (1985), Augustine (1987, p. 140).

5. Pooling of national production orders: Hartley (2017).

6. Public choice analysis: Hartley (2014, 2017).

7. Next seven countries combined: Freeman and Eoyang (2016). Roughly one-third: DoD (2016, p. 46).

8. Proposed USD54 billion increase: Shear and Steinhauer (2017). Military budgets in France, Germany, U.K.: Perlo-Freeman, *et al*. (2016). Foreign Military Sales: Weisgerber and Houck (2017). Saudi order: Jennings and Peacock (2016).

9. Other deals: Lockheed Martin (2017). BAE Systems: BAE Systems (2017).

10. U.S. military shipbuilding: Capaccio (2016).

11. Space-X challenging: Dillow (2016).

References

Augustine, Norman. 1987. *Augustine's Laws*. Harmondsworth, UK: Penguin Books.

BAE Systems. 2017. "F-35." http://www.baesystems.com/en-us/product/f-35 [accessed 21 March 2017].

Capaccio, Anthony. 2016. "Trump Would Get the 350 Ships He Wants Under Navy's New Plan." *Bloomberg*. 16 December 2016. https://www.bloomberg.com/news/articles/2016-12-16/trump-would-get-the-350-ships-he-wants-under-navy-s-new-plan-iwrthjb3.

Dillow, Clay. 2016. "The Great Rocket Race." *Fortune*. 26 October 2016. http://fortune.com/spacex-ula-lockheed-boeing-rocket-race/.

[DoD] U.S. Department of Defense. 2016. "Budget Overview: Fiscal Year 2017 Budget Request." February. http://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2017/FY2017_Budget_Request_Overview_Book.pdf.

European Defense Agency. *Defense Data 2014*. Brussels: European Defense Agency.

Freeman, Ben and Mieke Eoyang. 2016. "The President's FY 2017 Defense Budget." *Third Way*. 24 February 2016. http://www.thirdway.org/report/the-presidents-2017-defense-budget.

Hartley, Keith. 2014. *The Political Economy of Aerospace Industries*. Cheltenham, UK: Elgar.

Hartley, Keith. 2017 (forthcoming). *The Economics of Arms*. Newcastle, England, UK: Agenda.

Jennings, Garth and Lindsay Peacock. 2016. "Saudi Arabia Receives First F-15SA Eagle Fighters." *HIS Janes Defence Weekly*. 14 December 2016. http://www.janes.com/article/66203/saudi-arabia-receives-first-f-15sa-eagle-fighters (behind pay wall, only summary available).

Kirkpatrick, D.L.I. and P.G. Pugh. 1985. "Towards the Starship Enterprise—Are the Current Trends in Defence Unit Costs Inexorable?" *The Journal of Cost Analysis*. Vol. 2, No. 1, pp 59–80.

Lepore, Jill. 2014. "The Disruption Machine: What the Gospel of Innovation Gets Wrong," *The New Yorker*, 23 June 2014.

Lockheed Martin. 2017. "F-35 Lightning II: The Centerpiece of 21st Century Global Security." https://www.f35.com/global [accessed 21 March 2017].

Perlo-Freeman, Sam, Aude Fleurant, Pieter Wezeman, and Siemon Wezeman. 2016. "Trends in World Military Expenditure 2015." Fact Sheet. Stockholm: Stockholm International Peace Research Institute. http://books.sipri.org/files/FS/SIPRIFS1604.pdf.

Shear, Michael and Jennifer Steinhauer. 2017. "Trump to Seek $54 Billion Increase in Defense Spending." *The New York Times*. 27 February 2017. https://www.nytimes.com/2017/02/27/us/politics/trump-budget-military.html?_r=0.

Weisgerber, Marcus and Caroline Houck. 2017. "Obama's Final Arms Export Tally More Than Doubles Bush's." *Defense One Ebook: Foreign Military Sales*. (March).