REVOLUTION IN THE DEFENCE ELECTRONICS MARKET?

AN ECONOMIC ANALYSIS OF SECTORAL CHANGE

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Abstract

Within the defence sector there have been marked changes in the nature of the composite industries. This is particularly true of the electronics industry which continues to grow in importance, with electronic components built into nearly every weapons system and piece of equipment. Given the "Revolution in Military Affairs" (RMA) it seems certain that this growth will continue, impacting on both product and process. The result, however, may not be the contestable open market many expect (and hope for) as Network Enabled Warfare *may* result in new entrants, such as IT specialist and increased competition. Alternatively the nature of the market may continue to benefit the incumbents. This paper presents an analysis of the changes taking place in the industry using firm-level, primary, survey-based, qualitative data on corporate conduct. The results suggest that in practice the incumbents do seem to be in a strong position. The new demands of the customer require much more than mere technical capability. Specialists who do not have established industry relationships, who do not understand industry "protocols" and who cannot communicate effectively with the customer are unlikely to survive. This suggests that rather than new entrants, there may in fact be exits from the industry and further consolidation.

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1. INTRODUCTION

Within the defence sector, technological advancements have seen electronic components built into nearly every weapons system and piece of equipment. Combined with the "Revolution in Military Affairs" (RMA) and the attendant push towards "Network Enabled or Network Centric Warfare" (NEW), it seems certain that defence electronics will continue to grow in importance in the future, enabling far-reaching advances in military capability and efficiency. Electronics provide capabilities that are critical to defence requirements and the effectiveness and lethality of weapons systems are increasingly dependent upon the electronics subsystems they employ. In the case of aircraft, for example, multifunctional displays, communication control panels, and related electronic systems and components have spread throughout the airframe, not only to improve performance and mission capabilities, but also to reduce acquisition and operating costs. Solid-state, modular electronics, and other innovations such as "fly-by-wire" and "fly-by-light" flight controls, are replacing some of the conventional components, thereby eliminating the huge amount of wiring, hydraulic hoses and steel cables found on previous generations of aircraft (Leopold, 2002).

With the growth in importance comes growth in complexity: "The global electronics industry represents an increasingly complex landscape" wherein one finds an "increasingly complex supply chain" (Andrey, 2003). In this context, this paper makes an attempt to understand the developments in and changing natures of the industry. It presents the results of an analysis of recent firm-level, primary, survey-based, qualitative data on corporate conduct[1]. The next section considers the definition and nature of the industry, followed, in sections 3, 4 and 5, by an analysis of change in the sector at the levels of company, industry and supply network respectively. In section 6 these threads are drawn together in a consideration of competitiveness in the sector, which leads in turn to an exploration, in section 7, of what may be considered the main force driving change, the Revolution in Military Affairs (RMA) and Network Centric Warfare.

2. DEFENCE ELECTRONICS

The *defence electronics* sector of the industry is usually defined to include two main areas: military-specific electronic items (such as avionics and precision guidance systems), and commercial devices modified to meet military requirements (such as "ruggedized" laptops). However, the defence sector also makes extensive use of electronics throughout all its activities, from combat to logistics to base operations (NDU, 1996). Two problems arise immediately when attempting to define the extent of the defence electronics sector: "First, there is no official Standard Industrial Classification (SIC) definition of the UK electronics industry; and second, the defence component of the UK electronics industry is not officially identified."[2]

Analysis of the survey data from the defence electronics companies helps cast some light on this issue. The first thing to note is the fact that all companies interviewed reveal themselves to be part of larger diversified groups; this is clearly potentially significant when considering responses to subsequent enquiries regarding business conduct, strategy and disposition reported below. When attempting to define activity areas, a "product – business" split can be identified: in terms of *product*, this is a disparate sector, however, in terms of the companies' view of their core *business* it is uniform: When questioned about the company's

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[1] The data comes from a study commissioned by the industry trade association (Intellect) and the UK Department of Trade and Industry. See Dowdall, Braddon and Hartley (2003)

[2] To compound the problem, the authors point out how the definition of the national defence industry is changing, wherein "national" is currently viewed by UK Government as being where "where the technology is created, where the skills and the intellectual property reside, where jobs are created and sustained, and where the investment is made' (MoD, 2002). Such a definition includes foreign-owned companies with research and manufacturing facilities located in the UK" (Dowdall, Braddon and Hartley (2004).

main products, there was a variety of responses, but when questioned about the company's main *business* there was consensus: "solutions providers", "needs satisfiers", "systems integrators". Repeatedly interviewers were told how a company no longer viewed itself as a supplier of a discrete product or service but as a top-level provider of solutions. This is similar to the Ministry of Defence, Defence Procurement Agency response "…we previously bought products; now we seek to procure needs satisfaction." It appears then that some symmetry of role has developed between industry and customer.

3. DEFENCE ELECTRONICS COMPANIES AND TECHNOLOGY

Companies operating in this "sector" vary widely in terms of the depth of their involvement, with respondents reporting defence as 24% to 100% of their total business. In fact half of them reported 100%, reflecting the fact that they were part of larger groups, within which their functional role and remit is defence electronics. This meant diversification *at operating company level* was not an option. All respondents stated having no intention of leaving this business – although approximately half expressed a desire to reduce "dependency".

Those organisations that were exploring opportunities for diversifying their portfolios were largely doing so at the periphery of existing markets, where it required little or no further investment in research. Application areas include: police, ambulance, "detection" (chemical, biological), anti-terrorism, ports, liners, air traffic control, para-military, security, commercial transport, telecommunications, energy, media and finance. This pattern was observed over a decade ago by the UK Parliamentary Office of Science and Technology (POST, 1991). Some organisations approached it somewhat unenthusiastically whereas others had made a firm commitment at group level to the exploitation of such technologies[3].

The motivation for such activity was simple business pragmatism, the pursuit of profit and survival. Movement was demand driven and opportunities were explored where growth markets had been identified. There was no set pattern of diversification strategy– both organic (internal) and merger/acquisition (external) methods were reported. But one point was frequently repeated: it was the application of existing products etc to new markets, where no new R&D investment was required - a cautious, technology lead approach.

Another important development has been rapid growth in non-military commercial technologies, which has made civilian sectors the technology leaders in all but a few niche areas (Brzoska, 2001). It was widely predicted in the early 1990s [OTA, 1992; Gansler, 1995] that the combination of the concentration of technological advances in civilian sectors and globalisation would result in a higher degree of military-civilian integration of technology and production, in companies that primarily produce civilian goods and weapons on the side. It would thus lead to a 'civilianisation' or 'normalisation' of arms producing companies" (Brzoska, 2001). There is certainly evidence that technology transfer from the civil sector to the military is now a major force in weapons system development and will continue to transform both the defence industry itself and, more particularly, the defence electronics business (Ruecker, 2000).

The enhanced flow of cost-effective commercial technologies into military procurement is, however, not without problems. Many commercial research and development programmes tend to focus on 'near term technology with short-term payoffs' such as winning the next contract, rather than the longer-term technology developments required to ensure that defence capabilities remain 'leading edge' in nature (ICAF, 2001). Another issue is that of parts obsolescence. The extraordinary pace of change in electronics technology now ensures that many parts and components become rapidly obsolete, but military equipment programmes are expected to have long life-cycles, meaning virtually every piece of military equipment will contain obsolete parts. Yet, under current market conditions, vendors have no obligation or incentive to produce or retain stocks of obsolete parts, which can lead to problems (ICAF, 2001). In addition, the need to protect 'defence-critical' product and process

[3] Further examples of commercial application areas cited in interviews included: Rail, smart cards, civil aviation, satellite TV, healthcare, gyros, immigration, oil, satellite tracking and safety.

technologies, has been recognized particularly in the US and this is constraining the drift towards Commercial Off-The-Shelf (COTS) supply (National Research Council, 1999).

The survey results reflected these developments and showed a considerable overlap of defence and civil supply networks, especially at commodity level, with divergence only appearing "when 'defcons' dictate" and "specialist technical capabilities are specified"; the drive towards COTS being offered as one reason for commonality. Even with the low levels of involvement in non-military activities, noted earlier, the majority of survey participants reported a spin-in of technology from the civil sector. It was suggested that at component level, technology development is not defence-specific. When contractors were pressed about the exact point at which the technology development became specific to the end (defence) market, an equal number of respondents said very late and very early in the process. Those reporting very late stage talked of the need to make the end product "rugged" "deployable" and "secure"[4], while those early stage were very clear that they considered the defence requirements from inception. When asked about future trends in technology transfer between defence and civil application areas, as many respondents thought the level of *defence to civil spin-off* would increase as thought the level of *civil to defence spin-in* would increase. This spread might be expected given the range of products and services captured in the sector.

4. DEFENCE ELECTRONICS INDUSTRY

The restructuring of the defence industry represents one of the most dramatic industrial transformations in modern times (Wulf, 2001). Defence equipment development and production has become much more transnational in character with teaming and programme-specific joint ventures bringing together companies from a number of countries to meet procurement requirements (PREST, 2002). The defence companies themselves are also experiencing structural reorganisation and are becoming more transnational in both activity and ownership, through "… the growth of cross-border mergers, joint ventures and minority equity stakeholdings" (James, 2002).

In the defence electronics industry, the rationalisation and consolidation process has been most notable in the Unites States (SIPRI, 2003). Analysts suggest that the single greatest percentage of market share – almost one-half of the market - will go to groups of companies working together in project-specific partnerships or as "multi-contractors". The UK has also seen consolidation with many familiar names now lost inside larger groups. All, or part of the following have changed hands:

Racal	TI	STC
Plessey	Ferranti	Link Miles
Redifusion Simulation	Science Systems	Thorn EMI
Graseby Dynamics	Redifon	Alenia
GEC Marconi	Invensys	MEL
Smiths Industry	Nortel	Thompson-CSF
TRW	British Aerospace	Computing Devices

and "new" entities have emerged:

BAE SYSTEMS	Thales	Smiths Aerospace
Alenia Marconi Systems	General Dynamics	EADS
Qinetiq	Cogent Defence Systems	

Reflecting this, most respondents reported having been involved in merger/acquisition activity and many also reported concurrent involvement in divestment and rationalisation. Interestingly, there was general consensus amongst participants in this survey that there are few *new* competitors in this industry, just "re-packaged" groups; consolidation is producing larger competitors (there was some acknowledgment that there are new "niche

[4] Other defence-specific attributes such as size, speed and information style and format were also mentioned

players"). Similarly, it was felt there were no true exits from the industry only loss of identities through horizontal and vertical merger, acquisition and integration[5].

Incumbents consider themselves to be insulated from new competition due to the existence of certain "barriers to entry".

Finance – this is an expensive sector in which to compete, involving large scale investment in "highly evolved technology". At the same time, profit rates are controlled within MOD contracts.

Timescale – prospective competitors have to be sure they have sufficient funds and robust financial systems to accommodate the extremely drawn out development and production timeframes and gaps between initial investment and returns.

Knowledge, Reputation and Relationships – by far, the most frequently cited factors. Dealing successfully with government defence departments was considered to require "domain specific knowledge" and this knowledge of differing requirements, systems, procedures and protocols came only from experience. Of equal importance was knowledge and experience of other parts of the supply system: prime contractors and other systems (or sub-systems) integrators needed to have, readily available, detailed information on capabilities and resources scattered throughout the supply system that could be combined, often on a project-specific basis, in the face of vigorous competition. Minimising such search or transactions costs was seen as conferring significant competitive advantage and constituting a significant entry barrier. A similar situation exists for competitors further away from the end customer, where there is a need to be known by the systems integrators and have a good reputation. Such formal and informal inter-firm relationships make it extremely difficult for new entrants to develop the necessary linkages. This situation is likely to be intensified with the current UK MOD policy of reducing the number of direct suppliers and making increasing use of Industrial Prime Vendors (IPVs). Sub-contractors and suppliers will "need to establish new relationships with the IPVs rather than with the MoD directly" (MOD, 2004).

Such barriers suggest that contestability is low, meaning existing players believe they can act without fear of new competition from market entrants. There were, however, concerns among respondents that this comfortable environment was unlikely, as the move towards "Network Enabled Warfare" would herald the entry of a new type of competitor – "non-defence systems specialists" such as IBM, Logica, EDS, Serco. QinetiQ, previously the greater part of UK government Defence Evaluation and Research Agency, was also referred to as a new, powerful organisation that has the capability to compete in all parts of this sector[6]. Israel and Eastern Europe were also mentioned as potential sources of new competition.

Overall, the future looks decidedly uncertain when viewed from the perspective of the existing defence electronics contractor – on the one hand there is evidence of a feeling of insulation and protection but this is coupled with a growing unease about crumbling barriers and new competition.

5. DEFENCE ELECTRONICS SUPPLY NETWORK

One of the most striking features of the defence electronics supply network in the UK is its complexity. Survey participants declared how "… suppliers/customers/ partners are

[5] Interestingly, Marconi was frequently cited here – the industry clearly views this case as an exit

[6] BAESYSTEMS announced on 30 March 05 "… an alliance with QinetiQ to identify wider commercial applications and business opportunities for its defence and aerospace technologies." The agreement, which may be seen as an attempt to effectively reduce competition, "… initially lasts for six months and operates on a shared risk and rewards basis (and) requires QinetiQ to identify, validate and develop 'go to market' plans ... It also opens the door to a longer-term relationship between the two companies." (QinetiQ, 2005)

always changing positions – it depends on the specific venture." Detailed information about suppliers was rarely provided but it is interesting to note that when it was, the names were very familiar as, often, they had already been offered earlier in the interview process in response to questions on customers and/or competitors: eg BAESYSTEMS, Thales, EDS, Lockheed Martin, Northrop Grumman, EADS.

Whoever these suppliers were and whatever there inter-firm configuration, what was abundantly clear was that supplier lists were being cut dramatically (although the lengths of such lists vary widely from 30-40 to 3-4000). The drive towards shorter supplier lists was regularly described as a deliberate policy "of consolidation" and an attempt to improve quality. Additionally, there was evidence that the increasing pattern of sub-contracting at a higher level of sub-assembly was having the effect of reducing supplier lists.

Within these supplier lists are a much smaller number of "preferred" suppliers" who appear in various guises. On occasions respondents talked of formal preferred suppliers, whilst others referred to "de facto" preference and "cultural relationships". Certain organisations had "long term supply agreements," others had centrally negotiated arrangements negotiated at "group" level where certain "synergies" and "critical mass" could be achieved.

There was no consensus regarding geographic spread – an equal number of responses declared spread increasing as declared no change. Those who did say they were looking further afield said they did so in pursuit of quality, performance or lower prices. Much talk is of China as an emerging source of supply: a 2004 report by Decision Etudes Conseil, refers to "A new geographical pattern" suggesting that "by 2007 China will become a major player, with production at the same level as Europe and North America. China and the rest of the world will account for 40% of world production, and Europe, North America and Japan only 60%" (Decision Etudes Conseil, 2004).

6. COMPETITIVENESS

Costs: Technology transfer, the emergence of new technologies and products, and the 'Revolution in Military Affairs' all appear to offer significant potential cost savings to a defence sector facing tight budget constraints. It is here that the defence electronics industry makes a significant contribution. New avionics/electronics technologies such as flat, multifunction panel displays are more efficient and more easily replaced than previous equipment. Estimates suggest that the share of avionics and related electronics as a proportion of the total value of a military aircraft will increase dramatically over the next ten years from around 39 percent of the aircraft purchase price to more than 45 percent. For the new F-22 advanced fighter, for example, the value of the electronics is predicted to exceed 50 percent of the aircraft's purchase price. To reduce costs, existing military aircraft and missiles, for example, will be upgraded with new modular electronic systems, converting them into smarter weapons, surveillance and communications platforms, while also cutting acquisition costs by extending their life expectancies. Further cost savings will be achieved by the wider use of unmanned aerial vehicles that incorporate advanced electronic surveillance and communication systems.

As noted earlier, additional cost reduction and technology acquisition can also be pursued in the defence electronics industry through collaboration in the form of strategic alliances, partnerships or through offset arrangements. Actually achieving these potential cost savings and technology enhancements may, however, prove more difficult than imagined (McGuire, 1998).

Scale economies: When respondents were asked about economies of scale, they tended to respond that "our level of production is too small ... but, there again, yes, *hypothetically* … YES! Very important!". Production runs were considered extremely low: "one-offs", 12, 15 to 20, meaning potential economies of scale were never truly exploited but they did exist. As the scale was so small, unit costs were said to fall dramatically as output increased and those who provided estimates suggested a doubling of output from current low levels would result in average costs falling by 15%, 20% and even 66-75%. It is reasonably

clear that what is being described here is *not* "economies of scale" - it is the simple spreading of large fixed costs over a small level of output, that is, a short-run production function and not the long-run function more commonly associated with scale economies[7].

Learning or knowledge: Beyond the scale of output, it is held that the cumulative knowledge gained from the experience of repeating an exercise can result in lower average costs, even with small runs. Such reductions were said to be found in particular on the labour side and typically "kicked in" at the end of the first batch. While respondents attempted to retain this individual knowledge and turn it into organisational knowledge through good documentation, they also felt that "knowledge was dissipated and unlearned because of MOD batch ordering rather than continuous production." Contractors also highlighted the potential cost savings that can result from cumulative knowledge of the industry, the market and the supply network. It is likely, that as outsourcing increases that experience based knowledge of the supply network is likely to be the source of competitive advantage both domestically and internationally. That is, a firm may be able to realise significant cost savings through reduced "search costs".

International competition: When asked to reflect upon their average costs and those of their rivals, respondents generally felt that competitors in the UK had no significant cost advantages or disadvantages over each other and a few claimed cost advantages over their European rivals. They were, however, unanimous in feeling that UK contractors are at a significant cost disadvantage to their US rivals, simply because the volume of US production allows US contractors to reap the rewards of economies of scale. Respondents suggested that they competed on other aspects, their "responsiveness through lean manufacturing", their ability to "customise.", and their "ability to do the job."

Development time: Respondents were asked to compare their development time relative to their main rivals. First, it was clear that there is no typical development timeframe in this sector, but that modularity is driving down times. No significant differences were reported between UK and rest of Europe. US competitors were quicker for standardised products, but when new, innovative, customised or bespoke products were required UK contractors' flexibility gives them a potential competitive edge. There is evidence of antagonism developing between corporate and government strategy here. If it is true that UK defence electronics contractors are gaining certain competitive advantages from customisation and problem solving, then it is quite possible that this advantage may be seriously eroded by the MOD or prime contractor drive towards lowest price, COTS based, modularity and the associated standardisation.

7. FORCES DRIVING CHANGE - RMA

The economic and military significance of the so-called Revolution in Military Affairs is now being widely discussed in the literature (Matthews and Treddenick, 2001; Ignatieff, 2001; Hayward, 2001). RMA has become possible by technological developments in sensors, IT, communication infrastructures, satellite navigation and reconnaissance; all of which incorporate significant inputs from the defence electronics sector. A report from the National Defense University, Washington (NDU, 1996), suggests that modern warfare's command and control, intelligence, communications, logistics, and weapons systems will rely increasingly on electronics to provide the means to gain the necessary information advantage. This means there is now an increased emphasis on 'smart' electronic systems used in intelligence gathering and communications, as well as the more precise delivery of ordnance with a minimum of civilian casualties." (Ruecker, 2000). The ascendancy of terrorism, rogue

[7] It should be noted that the defence electronics contractors interviewed as part of this research varied dramatically in size. While many companies spoke of production runs below 20, the largest bemoaned orders of only 150 and referred to large scale as being 3000 (This, largest contractor took as its benchmark the order size enjoyed by US contractors).

states and organized crime in the post-Cold War, post 9-11, security environment has meant that the "quality of surveillance, communication and information management systems are at least as important as firepower and other traditional measures of military capability" (Kirkpatrick, 2004). A core component of new military doctrine is 'information dominance' (requiring capabilities included within C4ISR, command, control, communications, computer information/surveillance and reconnaissance) (Theile, 2000).

Respondents in the survey offered an interesting, and somewhat uncertain, view of the issue. First the "Revolution in Military Affairs" is actually known by the industry as "Network Enabled", or "Network Centric", Warfare. The impact of the was considered to be highly significant for both product and process innovation[8]. It was generally viewed as having a positive impact, although the more cautious suggested that whilst the impact would be significant they were "…unsure where, when and how." They felt that it would necessitate contractors developing "…a greater understanding of MOD needs … and should also mean MOD learns more about industry capabilities." Another expressed the opinion that it "…will allow us to show the customer (MOD) the benefits of COTS; trading off milspecs and commercial." A more critical view expressed concern about the MOD being "swept up in it" and "a system of systems is beyond capability."

Some respondents also suggested *possible* new competition coming from IT specialists such as IBM and Logica, but there was a greater belief that it may in fact have the opposite effect. It was contended that in practice the new demands of the customer in this environment will require much more than mere technical capability. Specialists who do not have established industry relationships, who do not understand industry "protocols" and who cannot communicate effectively with the customer will not survive. If the defence sector mirror those in consumer electronics, then consolidation is very likely. Kellender (2005) suggests that "many of the networked products now being developed will be replaced by a single box or hub" with a shift in demand towards the latter and a consequent industry shake out. This combination an increasing importance of the sector and the increasing concentration of suppliers is provoking concern about market failure: "In some areas where the private sector proves unwilling or unable to provide the goods and services which MoD requires, HMG may have no alternative to the creation of a public facility, similar to the Defence Microelectronics Activity (DMEA) in Sacramento which the US government has established to provide US forces with electronic components and subsystems which are no longer available from the private sector" (Kirkpatrick, 2004).

CONCLUSIONS

This paper has reviewed the restructuring of the defence electronics industry in the UK, using information from a survey of respondents. It has revealed considerable change and challenges for a strategically important industry and much uncertainty regarding future competitive conditions. A number of structural and behavioural patterns can be identified: The UK defence electronics firm is not easily classified – it is a disparate sector encompassing a large product range, with incumbents being the defence electronics division of large, diversified groups. As such, diversification at operating company level is often not a strategic option, other than at the periphery of existing markets. There is much merger, acquisition and concurrent divestment activity but few new entrants, merely new names as groups reconfigure and "re-package". Existing competitors consider themselves to be insulated from new competition due to the existence of certain barriers to entry, seeing

[8] Comments included:
"…it will affect everything!"; "It will impact on the business mix, capabilities, recruitment, growth..."; "The core market will drift … with a possible change in business process towards those found in the commercial sector."; "Everyone in the company in talking about it – it is our business … It will affect products, processes, R&D."; "…a revolution in information sharing."

experience and knowledge of the industry as an increasingly significant barrier to would-be entrants. In the face of Network Enabled Warfare and the Revolution in Military Affairs, it was held that the importance of "domain-specific" knowledge will increase and cost related competitive advantage will come from efficiencies in external search rather than internal production. Organisations who do not have established industry relationships, who do not understand industry "protocols" and who cannot communicate effectively with the customer will not survive. Not only may there not be new entrants, there may in fact be exits from the industry and further consolidation.

Whilst at this point it is not fully clear how these forces and developments will ultimately impact upon the sector, what this paper has shown is that the changes that are taking place represent important challenges to both the industry and to UK Government. In light of such developments it is suggested that a pure market-based solution is unlikely to produce satisfactory outcomes and consequently, the crucial issue remains whether the UK Government can formulate coherent research, acquisition and industrial policies, and whether it can evolve these policies to maintain their effectiveness in a fast-changing world.

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