Industry capabilities in software and systems integration

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THE REALITY OF DEVELOPING AND SUPPORTING MODERN MILITARY EQUIPMENT AND SYSTEMS IS THAT EMBEDDED SOFTWARE pervades the design of most products. Embedded software, the programs hidden inside systems or hardware require some very unique industry capabilities to both develop and maintain. In strategic terms this is a national capability. It is as important as the ability to shoot missiles or drop bombs, yet it is largely invisible in the ongoing public defence debate, and just as invisible in national strategic policy.

Historically, Australia has had some very good capabilities in this area, albeit not on the scale of larger nations with stronger industrial capabilities. The larger long-term concern is whether this capability, which is so vital to national defence capabilities, can be sustained and grown.

There is a common misperception, outside the community of embedded software practitioners, that embedded software and integration is much like any other software, and any 'code cutter' can produce either variety of software on demand. If only the world were so simple. For better or for worse embedded software and integration development skills are unique, requiring significantly greater breadth and depth compared to more conventional software development and integration.

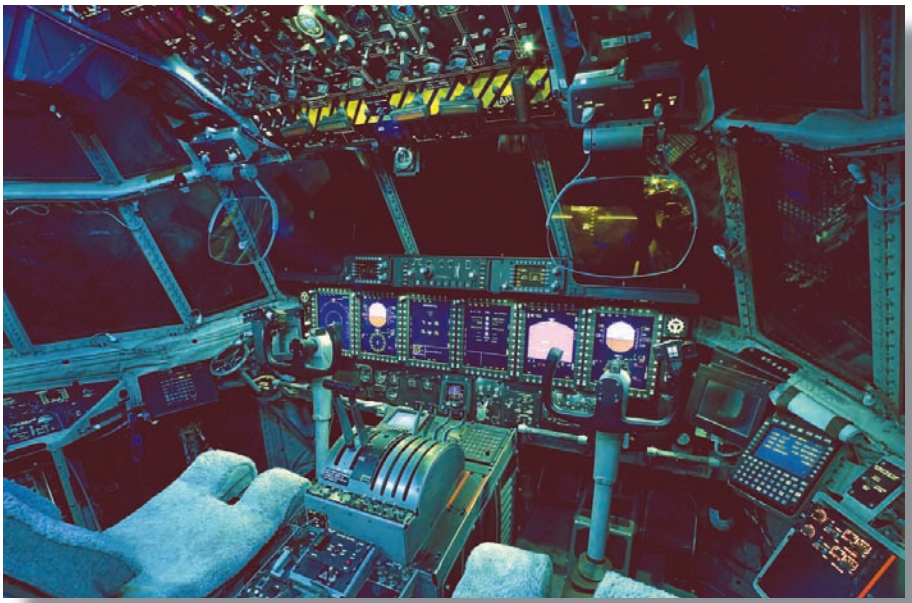
This is an important distinction. The problem solving approaches used, the mindset, and the software and hardware tools skills sets are so different that it can take many years to retrain a 'conventional' computer programmer to become a truly proficient embedded systems and integration programmer. Many programmers fail to acquire the necessary skills, as there is an element of talent required to be truly proficient in this skills area.

The importance of this skills area in the defence industry cannot be overstated. Not only is software pervasive in modern military systems and equipment items but also the ability to rapidly make changes to it can make a critical difference in a combat situation. This is because much of the functionality of modern military systems and the weapons they deliver is defined in the embedded software running on computer chips inside these systems. The reality of combat is that opponents will adapt, whether they are low tech players like insurgents, or sophisticated industrialised nations, of which there is an increasing number in this region. Countering an opponent's adaptations requires changing the behaviour of military systems and weapons.

In regional strategic terms, increasing numbers of fully digital weapons and systems are being fielded. These are mostly of Russian origin. Even China's defence industry is now rapidly growing capabilities in this area, riding on the back of its manufacturing industry and reverse engineering Russian technology. India has become already a major global player in the software industry. Whether we consider sensors like radars or platforms like warships or combat aircraft, the global trend has been toward systems that are digital, with key functionalities defined in software. This has been driven more than anything by the need for rapid adaptation of capabilities – the ability to change modes, integrate different weapons, or change the way a system responds to an opponent's countermeasures.

If Australia wants to have any credible military capabilities in this region, it will require the capabilities within its industrial base to perform embedded software development and systems integration on its key military platforms and systems. The alternative will be complete dependency on overseas provision of these capabilities, where nation state level conflicts of interest and prioritisation of national needs prevail over foreign needs. This would result in Australia losing the vital ability to adapt its platforms in a timely manner in any crisis or conflict situation. This is the reality of owning and operating complex high technology military systems and equipment developed by other countries. Unless there is true technology transfer, especially in the embedded software area, to local industry then the capacity to adapt is compromised.

Developing and maintaining a pool of personnel with the required skills sets is not an easy task, as the scarcity of required talent in any national gene pool compares closely to that seen in areas like fighter pilot or warship commander training. A frequent complaint heard is that it is difficult and expensive to recruit, train, sustain and retain operator personnel with key skills, and air force fighter pilots are the most commonly cited example. The problems



Major programs such as Boeing's C-130 Avionics Modernisation Program require a great amount of software development and systems integration, expertise that is a vital component of Australian Industry capability. (Boeing)

Australia's Wedgetail Early Warning & Control program, delayed by system integration and other issues, highlights why Australia needs to maintain an organic software and systems integration capability. (Boeing)

JORN project transmitter site, Laverton WA. (Photo: CPL Dave Broos, Defence Public Affairs)

Aircraft such as the Tiger Armed Reconnaissance Helicopter will require substantial software development and systems integration support over life-of-type. (Thales)

confronted by all industry organisations involved in embedded software development and integration are no different, as complex and usually expensive development projects are required to produce the necessary experience and skills sets, even if the required talent is available.

Recent trends have not been encouraging, at every level of this capability.

The principal training environment for personnel who will become future embedded programmers and integrators is the university system, primarily the engineering and computer science schools and departments in the Go8 universities. These have suffered an ongoing decline in undergraduate and masters enrolments in these disciplines over the past decade. While industry frequently complains to universities over the shortage of systems qualified graduates most Go8 universities have had to mothball elective units in systems and embedded programming due to a lack of interest from the student body because enrolment numbers have been too low to sustain the units. The lack of student interest reflects two realities: the first being that such units are amongst the most difficult to pass due to the technically challenging content, and the second being a perception in the student body that there are no good careers to be made in such work. These problems are further exacerbated by the higher cost to universities of teaching such units, as there is a need for expensive lab facilities and scarce tutors plus teaching personnel qualified in the area.

Universities currently teaching units in this area either at undergraduate or masters level include ANU, Griffith, Swinburne, and Flinders. Monash mothballed their unit due to poor demand in recent years.

A university bachelors or masters graduate is essentially raw material, which must be sharpened and hardened by exposure to real projects and practical experience. This has historically been the role of industry, using graduates to perform programming work on projects, but supervised by highly experienced embedded programmers and integrators.

This area has also presented difficulties in recent years, primarily due to the heavily fluctuating demand between contractors and projects, in turn reflecting the ongoing volatility in the Defence contracting business globally, and in Australia. The current trend in many parts of the industry is to minimise investment in permanent personnel and exploit contractors or outsource the work, as the latter is cheaper in terms of recurring investment. While it might look better on the balance sheets, the strategy of not spending money on the development of such skills sets is as a whole deleterious to the industry, as the pool of personnel with required skills sets and experience cannot be grown at a rate required to meet surges in demand or contingencies, and attrition replacement demands for personnel who leave the industry sector cannot be easily met.

There are a number of defence contractors that have capabilities in embedded software and systems integration. These include some of the large foreign-owned primes and a good proportion of the Australian owned SMEs. Players in this capability area include Acacia Research, Adacel, Auspace, Avalon Systems, Boeing Australia, CEA Technologies, Computer Sciences Corporation Australia, Compucat Research, CPE Systems, Daronmont Technologies, Dspace, Lockheed Martin (formerly RLM), Raytheon, Tenix Australia / BAE Systems, and Thales Australia.

Surveying specific capabilities by contractor is an interesting challenge, as personnel numbers continually fluctuate with varying project workloads, and the often large fraction of contract personnel on specific projects.

Capabilities can be broadly divided into categories. The first is the capability to integrate and maintain core software and systems for major platforms. In Australia this has been primarily in the area of naval systems, with the sole exception of the Boeing-run capability for the F-111, which is now being dismantled.

This 'first tier' capability is by far the most challenging to sustain. It requires that major force structure platforms have a complete in country systems integration, software development and maintenance capability along with a permanent pool of properly skilled personnel. It also requires a sustained volume of workload on a scale sufficient to maintain personnel skills, train replacement personnel, and provide sufficiently intellectually challenging new tasks to retain the best talent, which might otherwise migrate to intellectually greener pastures.

The history of this capability in Australia is characterised by poor support from Defence over the last decade, and an increasing propensity to outsource this capability overseas.

The second tier in the heirarchy of capabilities is the ability to develop and maintain software in major items of equipment other than major platforms. This could involve equipment such as radar, electronic warfare equipment, widely used networking terminals, or other systems of critical importance in capability terms or in numbers within ADF service.

In this area Australia is doing only slightly better, with the statistical proportions being strongly skewed by domestic programs like the JORN (RLM/LM) and SECAR (Daronmont), naval radar equipment (CEA Technologies), and numerous systems and equipment items built or integrated by other domestic contractors.

The long term challenge is ensuring that these organisations, especially the SMEs, have a sufficient volume of ongoing business to sustain their software development and integration capabilities. It is well known that the Melbourne job market experienced a glut of programmers when the main integration effort on the JORN was completed. Many of these highly experienced personnel ended up back in the commercial programming sector since there were no defence projects to go to.

The third tier in the hierarchy of capabilities is the ability to develop and maintain embedded software in smaller items of equipment and specialised or unique systems. Good examples might be software radios, encryption equipment, specialised analysis tools and test range instrumentation, plus other items of specialised embedded military equipment. This is another area where Australia has some excellent capabilities in the SME domain, but again numerically limited by the nature of the products themselves. Much the same challenges arise as with tier two capabilities, except that the larger proportion of SMEs in this area, and the lower volume of products, make contractors in this category far more vulnerable to loss of personnel due to fluctuating demands for products.

The problems facing Australia in this area are not unique. The strongest players who are least exposed in this area are the US, EU, Russia and China, with large defence industries and large and sustained volumes of new business along with ongoing upgrade business on equipment exported during the Cold War era and since.

Interesting case studies for Australia are nations such as Israel and Sweden. They have developed strong domestic defence industries and now have robust domestic capabilities in embedded software development and systems integration.

Common to both of these nations is that they develop and maintain domestically almost everything they can, importing only those items of technology that are too big, expensive or technologically complex for them to develop on their own. Moreover, both nations have a strong export market built up over the last five decades, providing specialist niche products, often very innovative, in markets not occupied by the major players.

The current trend we see in Australia, especially in military aerospace, is diametrically opposed to the Israeli/Swedish model in that, increasingly, major and minor industry capabilities are being wholly outsourced overseas. Not only is the organic internal support base and technological skills set

within the ADF and Department being progressively eroded, but also the domestic industrial base especially in the areas of embedded systems and integration are being deeply damaged.

If this trend is sustained over the medium to long term, the short term damage to these critical industrial capabilities will become permanent and the skills base will effectively vanish. This is not without precedent in the recent history of Australia's higher technology industries. Fifteen years ago, Australia had two SMEs manufacturing top tier computer hardware; neither exist today. Restarting that industry capability will be problematic due to the loss of experienced personnel to jobs overseas and the reluctance of many key personnel to return to that sector.

The reality is that national industrial capabilities remain a critical part of the overall national capability to deliver and sustain military power. This was well understood during the 1940s, but since then has increasingly fallen into the category of public relations statements on 'self reliance' rather than fundamental policy principles.

Why is this? The last time Australia faced a genuinely technologically competent regional adversary in combat was during World War II. While Australian Meteor fighters were outclassed by MiG-15s in Korea, that was a distant expeditionary conflict in which Australia was not a major player. Since then, Australia has not confronted a technologically competent adversary in combat and this has clearly produced a misperception within Defence that future adversaries are not going to be particularly competent technologically.

The strategic reality Australia now confronts is a rapidly industrialising region in which many nations are now approaching or have achieved First World levels of technological competence. The long term outlook is that most nations in Asia will become technologically competent, and they will have access to military technology and turn-key support from nations like Russia, India and China. These countries have deep technological competencies in military platform, system and weapon design.

If Australia intends to punch at its weight, let alone above its weight, it will need to fundamentally change how it views and manages its defence industrial base. The most critical component in that industrial base, in terms of being able to rapidly adapt to a complex and rapidly changing technological environment, is the capability to develop and maintain embedded software and perform system integration.

What must be done to get Australia's industry into the position it should be, so that it can provide this type of capability on the scale required to credibly support the ADF?

The first step is to reverse the current drive to outsource these key industrial capabilities overseas. Until that happens, all other measures will fall on barren ground. The Defence organisation needs to abandon its long held internal mantras about the superiority of large foreign-owned and based contractors. A domestic industry cannot be successful, let alone become viable at exporting product, until it has a robust and stable domestic customer. For defence industries, that customer is the Defence organisation.

The second step is to change the funding and capitalisation environment in which Australian industry operates. Canada represents an excellent case study, as it has developed at federal and state government levels research and development cash incentives to make it attractive to start up and sustain companies operating in high technology sectors, including software and systems integration. Canada as a Commonwealth nation is much closer to Australia in terms of its machinery of government and its legal and financial systems than, say, Israel and Sweden, so it would be easier to adapt these schemes to the Australian environment. One interesting scheme Canada has introduced is a mandatory requirement that superannuation funds invest a proportion of their funds in domestic high technology industries.

The third step is to provide material incentives for undergraduates and industry personnel to educate themselves with foundation skills so they can become effective practitioners in embedded software development and systems integration. The best mechanism for this are academic achievement based scholarship schemes for university undergraduate and graduate degrees in Computer Science and Engineering, with a mandatory focus on embedded software development and systems integration. There will be no shortage of universities happy to provide courses and postgraduate supervision, if there is a sufficient pool of fully funded applicants.

In conclusion, there are some deep and fundamental policy changes required if Australia is to have the industrial capabilities in embedded software and systems integration required to credibly support the ADF in the extant and future regional strategic environment.

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