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INTEGRATION: WHY DO IT? WHAT DOES IT MEAN?

Point of contact: Simon Ng

Simon Ng
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7944
Fax: +61 3 9626 7084
Email: Simon.Ng@dsto.defence.gov.au

Daniel Hall
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7949
Fax: +61 3 9626 7084
Email: Daniel.Hall@dsto.defence.gov.au

Ruth Gani
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7301
Fax: +61 3 9626 7084
Email: Ruth.Gani@dsto.defence.gov.au

Thea Clark
DSTO Melbourne
506 Lorimer Street, Fishermans Bend
VIC 3207 AUSTRALIA
Phone: +61 3 9626 7059
Fax: +61 3 9626 7084
Email: Thea.Clark@dsto.defence.gov.au

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Simon Ng, Daniel Hall, Ruth Gani and Thea Clark

DSTO Melbourne
506 Lorimer Street, Fishermans Bend, VIC 3001 AUSTRALIA
Phone: +61 3 9626 7944 Fax: +61 3 9626 7084
Email: <first>.<last>@dsto.defence.gov.au

ABSTRACT

The term ‘integration’ is used widely within the Defence community in a number of different contexts. Recently, the concept of ‘Integrated Capability Sets’ (or Mission Capability Packages as they are also known) has gained momentum as a way of viewing, discussing and analysing the totality of Defence capability. Integration is generally seen as being a positive thing to apply to capabilities. However, little is recorded about what form of integration is appropriate (e.g. horizontal or vertical integration) or which domains should be integrated (e.g. technical, organisational or procedural). Of even greater concern is the lack of understanding of the reasons behind the push to integrate; what *values* does the integrator wish to enhance? This paper discusses the range of values that may drive the integration process, some of the risks associated with integration, and explains some of the forms that integration may take. The need to consider integration as a trade-off between risk and value is emphasised and a tentative mapping of integration to combinations of different risks and values is provided. In addition, a number of ‘all-round’ integration forms are identified which exhibit a minimum of risk. Finally, some of the values and risks associated with a particular form of integration are illustrated with a simple ‘Integrated Air Defence’ case-study.

INTRODUCTION

In 2000, the Australian Defence White Paper, *Defence 2000: Our Future Defence Force*, was publicly released by the government. It outlined the future vision for the Australian Defence Force (ADF), and has been used since to guide capability development programmes. Specifically, the White Paper outlines a set of key principles that should be used to guide capability development. One of these, in particular, has shaped the focus of the Australian Defence Organisation:

> '[How] different elements of capability, and different capabilities themselves, work together are critical to the effective conduct of operations. We have therefore sought to consider how the elements of the ADF can best work together to provide an integrated set of capabilities.' (Department of Defence, 2000)

The Defence Minister, Senator Robert Hill, reaffirmed this emphasis on integrated capability in a speech he made to the ADF Network Centric Warfare Conference on 20th May 2003:

> 'In the past we have focused on improving our force elements as individual capabilities. In developing the roadmap for the future we must focus on improving our understanding of the way in which people, systems and platforms link with each other and contribute to achieving the effects that we require. Our approach must be to integrate new capabilities within the force as a whole.' (Senator Robert Hill, 2003)

The focus on integration has encouraged various enabling organisations within Defence to align with the government's stated desire and create teams to investigate 'integrated capabilities'. However, while integration and 'integrated capabilities' are frequently spoken of, their meaning is often less than apparent. Definitions for the term 'integration' do exist, but are terse and, therefore, only partially satisfactory for the purposes of capability development.[1] Further, only vague references are made to the reasons for wanting to integrate.[2] In other words, no-one has yet made a concerted effort to articulate the two critical questions regarding integration:

- Why should we integrate?
- What does 'integration' mean?

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[1] A typical dictionary definition, '…to combine or be combined to form a whole…' or '…to bring or come into equal participation in an institution or body…' (Weiner and Simpson) is succinct, but not particularly useful. The word integration has its origin in the Latin *integrare*, meaning to 'make whole'. *Integrare* is from *integer*, meaning 'whole, intact'. In this sense, the term integration has about it a connotation of unity or global identity.

[2] For example, 'Technology offers new opportunities to work together, and to deepen cooperation in many areas. It also provides new imperatives to achieve closer integration and interoperability of capabilities and systems' is one of several references in the White Paper (Department of Defence, 2000) Australia's capstone doctrine, *Force 2020*, outlines a '…seamless force [as] the CDF's vision for the future ADF…', arguing that 'seamlessness' [sic] goes '…beyond the joint force, and envisages a force that is seamlessly integrated on two levels: where the single services are integrated operationally with each other, and externally – or cross functionally – with the range of supporting (or supported) agencies.' (Department of Defence, 2002, p17)

Keeping in the spirit of ‘the means serving the ends’, the following paper will address these two questions in the order they are presented. From this discussion, a framework bounding the concept of integration is offered, and the costs and risks associated with integration in its various guises are highlighted, especially with reference to the concepts of Network Centric Warfare. Finally, a case study is presented that illustrates the concept of ‘integration’ as presented herein.

WHY INTEGRATE?

Defence publications leave no doubt that integration is deemed desirable, but rarely do they give a case for why this might be so. To better understand the benefits (perceived or real) accompanying integration, a review has been conducted of integration across a broad spectrum of domains, from Defence and commercial industry through to politics and technology. In reviewing each case, an attempt has been made to identify the ‘why’ of integration: why is it being undertaken? Why is it desirable? This has produced a list of values that integration, of one sort or another, strives to support. It is these values that provide a clue as to where, when and how integration might be undertaken within the context of other concepts pertinent to Defence, such as Network Centric Warfare.

Integrate for Efficiency:[3] Byars cites an integrated approach to air defence as a means for rationalising resources (amongst other things) between the US Army and the US Airforce, particular in regards to manpower, organisational development and capability acquisition: ‘…[the Air Force] will transfer Reserve component manpower spaces to the Army if air base ground defense requirements exceed Army capability’ and therefore, by inference, improving the efficiency with which resources are expended (Byars, 1985). Changes in training approaches, such as with the integration of the sexes into single training programmes, have also been undertaken, at least in part to reap perceived efficiency gains by rationalisation of the development, conduct and support mechanisms for basic training (Gebicke, 1997).[4]

Integrate to Coordinate: The history of systems integration starts with integration as a means for improving coordination. As part of the US National Security Act of 1947, the intelligence services were ‘integrated’ under the control of the Director of Central Intelligence in an attempt to improve coordination of various intelligence activities by removing bureaucratic barriers and associated interests

[3] Efficiency is used as it has previously been defined in Brown, Hibberd & Ng: Minimising program inputs for a given level of programme outputs (or maximising program outputs for a given level of inputs) (Brown, Hibberd and Ng, 2003).

[4] *Defence 2000*, the ADF White Paper, makes reference to the perceived efficiency gains associated with integrating training programmes under a single umbrella programme: ‘In recent years, Defence’s delivery of education and training has changed significantly. Central to these changes has been a continuing shift towards a more integrated approach covering the common needs of both military and civilian personnel, including through the rationalisation of existing institutions and courses. The result has been greater effectiveness and efficiency’ (Department of Defence, 2000).

(Sapolsky, 2003).[5] Integration was also pursued as a means for improving coordination within the US Navy's ballistic missile technology development programme. In each case, the integration at the organisational level was designed to improve coordination of strategy, in intelligence collection and analysis and in ballistic missile development respectively.[6]

Integrate for Control: Whilst coordination is the process of aligning disparate—but not necessarily sub- or supra-ordinate—processes, integration can also function to increase control. R&D efforts have been traditionally integrated into commercial firms because of the difficulties of defining requirements and writing contracts for an area '…whose output is…uncertain and idiosyncratic' (Pavitt, 2003). The inclusion of the R&D effort within the organisational structure of the commercial firm provided better means for monitoring and controlling an activity that is inherently independent. In a study of integration within the Warsaw Pact, Volgyes writes of the integration of the Pact armies into the Soviet war machine by '…placing daily operational control in the hands of Soviet officers', providing a somewhat cynical example of integration undertaken to control forces that otherwise might have proven irritatingly independent (Volgyes, 1989).[7]

Integrate to Expand Scope or Scale: This value and the next are often presented as a duality.[8] The ability to make the most of established strategies, processes or products is often thought of in terms of expanding scale or scope. Commercially, integration to expand is typically associated with mergers and acquisitions: of like businesses, such as the acquisition of a newspaper by a media mogul in order to expand scale of product and market; or of unlike businesses in order to expand into other market areas, such as a sedan manufacturer buying out a four-wheel drive manufacturer in order to expand its range of products.

Integrate to Innovate: Innovation is the ability to produce new solutions, either in the face of new capabilities or due to changes in the outside context. The introduction to *The Business of Systems Integration* (Prencipe, Davies and Hobday, 2003) defines systems integration as '…an emerging model of industrial organization whereby firms and groups of firms join together different types of knowledge, skill, and activity, as well as hardware, software, and human resources to produce *new* products for the marketplace' [emphasis added]. Integration can provide a capacity to innovate by allowing various components—in the above

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[5] History suggests that the integration didn't realise its intended purpose.

[6] The latter is of particular interest, because it provides an example of extensive integration: the Navy's Special Projects Office managed and coordinated the '…development of specialized submarine navigation equipment, missile guidance and launch systems, the missiles themselves, crew training facilities, special communication facilities, and support bases' (Sapolsky, 2003).

[7] Under this regime, Pact armies worked within the framework of Soviet military culture. Other mechanisms of integration were also used to exert control: adoption of a common set of cultural values; adoption of Russian as the 'career' language; and homogenisation of forces by integrating ethnic groups across units instead of concentrating them within units. Tellingly, this form of integration only partly achieved its stated aim of control, providing yet another example of where the 'means' doesn't achieve the desired 'ends'.

[8] For an introductory discussion of this duality, see Axelrod and Cohen (1999) *Harnessing Complexity: Organizational Implications of a Scientific Frontier*, New York, The Free Press.

case, firms—to come together to provide new solutions. A tacit implication is the transience of the integration, indicating the significance of modularity and the concept of Mission Capability Packages (MCPs), and these are discussed in more detail in the next section. This value is often linked to the previous one: an expansion of scale or scope can result in synergies that aren't necessarily apparent.

It is important to note that the values listed above, while representing the core values motivating integration, are not the only desirable values for an organisation. Integration is not undertaken to pursue other values, such as robustness and resilience, although this does not necessarily infer that they are incompatible with integration.

The identification of values associated with integration is important for at least four reasons. First, it takes an effects-based approach to the decision of whether or not to integrate by providing the associated ends that integration strives to attain. Secondly, it provides the basis for understanding which manifestations of integration are appropriate and what trade-offs they might entail. Thirdly, it allows integration to be related to other concepts, such as Network Centric Warfare. Fourthly, it is a first step in defining measures of performance for any integration strategy, helping to determine whether or not given an implementation strategy achieves what is intended.

WHAT DOES 'INTEGRATION' MEAN?

This paper will develop a framework for understanding 'integration' by identifying its various characteristics, and by then relating these characteristics to the values identified above.

Global vs Local Function: Integrated systems have a global function or unified purpose. When components integrate, they don't merely interact, they interact with an agreed to higher purpose. In this sense, a combined arms team has a systemic property that is not linearly related to the component properties. Global function implies that the individual characteristics of the components are shaped by how they operate together as a system and not by any desire to optimise the component against its own internal criteria. Indeed, it has been demonstrated by Kaufman that, in systems with high degrees of interdependency, optimising the individual components won't necessarily optimise the system (Kaufman, 1993). Integration implies that this is understood, and that the integrated system is held to be paramount. An integrated system is one that has an identity of its own, and a global function or system-level purpose that, to a large extent, supersedes the purposes of the subordinate components. On the other hand, non-integrated systems have local functions. Their performance, design characteristics and optimisation solutions are a function of locally established criteria.

Loose vs Tight Coupling: Integration implies a degree of coupling of or dependency between components or steps. In other words, this characteristic implies that components in an integrated system have value only in respect to their relationships to other components in the system. According to Czerwinski, loosely coupled systems are those typified by '…decentralized operations, mission orders, ambiguous performance standards, and flexible control mechanisms', while tightly coupled systems are '…highly centralized and rigid [with] output…closely monitored within specified tolerances [and where] subsystems are interdependent'

(Czerwinski, 1998). In tightly coupled systems, changes or failures in any one part bring the whole to a halt. Loosely coupled systems are less prone to total breakdown because a greater degree of 'slack' exists within the system: processes do not have to occur in strict sequence; alternate service providers exist in the event of one failing to perform its function; standards are not rigid and so can be met more easily and more expediently.

Vertical vs Horizontal Approach: Vertical integration can be undertaken upstream, into the supply chain, or downstream, into service provision. Upstream vertical integration has been a common organisational method for controlling, protecting or even monopolising resources essential to the production cycle. By integrating the supply chain into the organisational structure, businesses no longer need to rely on less binding commercial agreements and exchanges to ensure access to the resources they need to fabricate their products. Ford's manufacturing line provides a good example of upstream integration: to ensure that the production line ran smoothly, each serial step of production was synchronised to the slowest step, guaranteeing that no downstream stage became bottlenecked or idle during production (Sako, 2003). Downstream vertical integration is generally used to ensure better exploitation of an existing market. It provides turnkey solutions to the consumer, and therefore ensures the relevance of the provider in the transaction.

Integration may also occur horizontally—that is, in a peer-to-peer sense, or at the same level in the value chain. Two aspects of horizontal integration can be differentiated: a more traditional horizontal integration involving acquisition and merger and a less traditional, but increasingly more common, form of horizontal integration akin to collaboration.[9] The second aspect of horizontal integration is more akin to the formation of partnerships or cooperatives between peer components (it may occur in combination with the development of new hierarchies). An example of this type of horizontal integration in Defence is the combined arms approach to land warfare. In a combined arms team, units are constructed of heterogeneous components or capabilities: one capability does not take precedence over another within the unit; instead, they function together to form a system that is synergistically more potent. The peer-to-peer relationships that form in Silicon Valley provide another example of horizontal integration.

Transient vs Permanent Association: Integration is not necessarily a static, permanent arrangement. Best discusses how '…specialist companies can integrate, dis-integrate, and reintegrate with other companies as technologies and market opportunities change' (Best, 2003). He likens the process of constant reconfiguration of networks as a form of '…self-assembling or self-organizing mode of regulation', drawing parallels with biological systems. Transient integration occurs when components come together temporarily in order to address a specific problem or capitalise on a specific opportunity. Transient integration combines components with different specialties as and where needed, allowing integration to occur in response to a dynamic environment, as in the concept of the

[9] Alberts and Hayes report on a comparison of network structures and how they impact problem solving, in which it was found that hierarchical networks were faster at solving a problem, but slower at learning (Alberts and Hayes, 2003) By inference, horizontal integration may very well favour learning over speed.

Mission Capability Package (MCP).[10] Such modularisation is only possible where a degree of technical convergence has occurred—that is, where the domain of any given component is sufficiently developed so as to have applicability within a range of different relationships and contexts. Permanent integration (really long-term or indefinite integration) provides more opportunity to rationalise.

Linear vs Complex Interactions: The traditional hierarchical structure in industrial era organisations is typical of linear interactions. According to Czerwinski, '…linear interactions describe highly structured systems which are logical, sequential and planned' (Czerwinski, 1998). They occur in series and tend to have only low levels of feedback, making the outcomes of failures predictable. In contrast, complex interactions describe situations in which the interactions between components within a system are not ordered or sequential, and where feedback persists. This tends to increase uncertainty, and put a premium on independent decision-making.

These characteristics are, of course, related, although they remain analytically distinct.

IMPLICATIONS FROM THE FRAMEWORK

It is possible to relate the characteristics identified for integration to the values discussed earlier. Table 1 gives a necessarily simple view of how the various approaches to integration relate to the values identified. Ticks indicate where a particular integration type favours achieving a given value. In some cases, an integration approach may result in an unfavourable outcome in one or more values, as indicated by a cross. The relationships in this table are indicative rather than firm, but they do provide a clue as to the type or approach to integration needed in order to support various desired values. For example, if careful control of a total process is desired, then integration of the stages of that process in a vertical (or serial) structure, with linear interactions between each stage is the preferential form of integration. The cost is a sacrifice in the ability to innovate, because such a carefully constructed process is likely to be highly rigid and easily disrupted.

[10] In the MCP, various capabilities are brought together under a shared command structure so as to provide the right mix to perform a given mission. When the mission is complete, the modular components are separated and distributed elsewhere.

Table 1 The relationship between the characteristics of integration and the values integration is assumed to support.

value	direction		attachment		coupling		interactions	
	vertical	*horizontal*	*transient*	*permanent*	*tight*	*loose*	*linear*	*complex*
control	✓	-	-	✓	✓	✗	✓	✗
coordination	-	✓	-	✓	-	-	-	✗
scope or scale	-	✓	✓	✓	-	✓	-	✓
efficiency	-	✓	✗	✓	-	✗	-	✓
innovation	-	✓	✓	✗	✗	✓	✗	✓

The relationships identified in Table 1 provide a clue as to the integration model that best suits specific needs. A simple analysis provides a glimpse into the integration strategies that provide outcomes in favour of particular values, revealing several lessons. The first two lessons are:

- *Control* and *innovation* are trade-off values. It is difficult to achieve both simultaneously.

- *Efficiency* and *innovation* are trade-off values, although the trade-off is not as marked as it is for *control* and *innovation*.

These are relevant to understanding the relationship of integration to Network Centric Warfare. Gholz lists amongst the aspirations of NCW the ability for '…more decentralized…forces to work together as a system' with the ultimate goal to increase the force's effectiveness at '…traditional missions…and [to prosecute] missions that would otherwise be too difficult or dangerous' (Gholz, 2003).[11] In other words, NCW hopes to allow innovative use of capabilities to take advantage of or respond to changes in context. Alberts and Hayes have identified two force-level (enterprise-level) attributes necessary to become a network-centric force—agility and interoperability.[12] Agility is central to the NCW force. Alberts & Hayes consider it to be comprised of six attributes: robustness; resilience; responsiveness; flexibility; innovation; adaptation. A force with these attributes will have the agility appropriate to the NCW concept, which will allow it to perform as an edge organisation in a dynamic environment (Alberts and Hayes, 2003).

[11] Alberts and Hayes report on such an integration process in which a group of knowledgeable individuals form ad-hoc teams to solve particularly challenging problems devised by Microsoft as part of its promotion of the Spielberg movie 'A.I.' (Alberts and Hayes, 2003)

[12] These attributes are in addition to specific mission- and task-related capabilities necessary for NCW.

Integration approaches compatible with NCW's desire for an innovative, flexible force are those that enable innovation. By their nature, such approaches sacrifice *control* and (to a lesser extent) efficiency.[13]

The next two lessons are:

- It is possible to achieve advantages of *scale/scope* and to be *innovative* if the integration is undertaken carefully—namely, a loosely coupled, complexly interacting and transient model.

- *Scale/scope* is supported by loosely coupled, complexly interacting horizontally structured integration approaches.

Integration factors that provide a system with the ability to innovate also provide the system with the ability to exploit scale and scope. Again, this provides agility by allowing a system to be constructed according to the requirements of context. MCPs, a central idea in NCW, represent an integration approach that supports scale/scope and innovation, values consistent with the NCW concept. However, such transient integration places pressure on the social element of trust and on the legal framework within which such systems form and reform. In addition, a key enabler of this approach to integration is the maintenance of a system view of the interacting components. It isn't always possible for the components themselves, who tend to be structured for deep rather than broad learning, to maintain this global view.

Expansion of scale and/or scope may bring with it a resource overhead to deal with social, policy and process interoperability issues and the associated disruptions to the components of the system. Significant effort might need to be expended to realise the benefits. As a consequence, efficiency may decline during the integration period as the components adjust to the new global function or internal interfaces.

The fifth lesson is:

- *Efficiency* is best served through the adoption of permanent structures.

Permanent integration makes it feasible to rationalise or fine-tune the components in the system, providing significant opportunities for efficiency gains. A permanently integrated system can be highly specialised to perform in a particular environment with tight coupling throughout. Since little or no change is envisaged, the system can forgo catering for environmental change and make many assumptions about the space it will operate within. However, this can leave the system vulnerable to unforeseen changes within that environment because integration approaches that support efficiency tend to sacrifice the ability to innovate. Defence is said to be operating in an ever-more-rapidly changing world. Permanent structures and efficiency may be the first sacrifices Defence organisations have to make if they are to meet the agility requirements of this new world.

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[13] Alberts and Hayes discuss emergent command and control as a product of the network, but it is not yet clear whether such a concept will self-generate from a networked force (Alberts and Hayes, 2003).

The sixth lesson is:

- *Coordination* is a characteristic of most types of integration. The highest degree of *coordination* is achieved by integration that is horizontal, permanent and linearly interacting, but this is only a matter of marginal superiority over most options. The worst cases correspond to vertical, transient integration.

This lesson is critically important as Defence pursues NCW. Coordination is more than interoperability: certain integration approaches support coordination. While coordination is often assumed to arise from the adoption of a set of standards[14] (and a resultantly high degree of interoperability[15]) organisational structure and attributes are a significant determinant. Some integration factors that enable coordination, such as permanent attachments and linear interactions, do not necessarily favour the other NCW values, such as agility.

This lesson also speaks to the difference between integration and interoperability: In contrast to interoperability, integration treats the component as merely a subject to the system totality. In a sense, it sets the design and optimisation of the system as pre-eminent, with the sub-components accommodating this—that is, in an integrated system components are integral, not supplementary. If integration were to be pursued to improve coordination, it wouldn't be limited to the adoption of standards; it would encompass an examination of how the various components interact and how their functions are arranged in time and space so as to achieve maximum coordination. Being integrated is not the same as being interoperable, although interoperability is an important enabler of integration.

In addition to these six lessons, another important seventh lesson can be identified:

- An 'all-round' set of integration models exists. This all-round set primarily consists of horizontally organised cases, with little sensitivity to other integration characteristics.

These models don't excel at supporting all values, however, they do provide some benefit in several areas while not directly penalising those areas where a benefit is not forthcoming.

CASE STUDY: AN INTEGRATED AIR DEFENCE SYSTEM

Examination of a simple case study may help to illustrate some of the aspects of integration that have been discussed in previous sections. Air defence is an area where integration is often seen as a key 'force multiplier' i.e. something that can increase efficiency and allow for synergistic gains. A comparison of a generic non-integrated

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[14] Standard (performance and interoperability) qualities need to be maintained; it is tempting to start with the lowest common denominator, potentially shackling higher performing components to the same regime as the lower performing ones.

[15] Interoperability is 'the ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together' (Joint Chiefs of Staff, 2001, p 272). It is a description of a capacity to interact in a certain way; as such, it presents an important constraint or requirement on the component solution.

system and a generic integrated system are given here in order to illustrate some of the benefits and risks associated with integration.

The mission of both systems in this case study is to identify threat aircraft and shoot them down. At a very basic level, an air defence system contains the following functional components:

- A sensor (typically a radar). The sensor produces an 'Air Picture' which displays tracks of aircraft within the range of the sensor;
- A decision maker. The decision maker uses the Air Picture to identify threat aircraft; and
- A shooter. Once a track has been identified as a threat, the shooter fires a missile at the aircraft.

Both the sensor and the shooter have a limited range. So, in order to protect a given area against air threats it is necessary to have a number of geographically distributed air defence 'cells', containing sensors, decision makers and shooters.

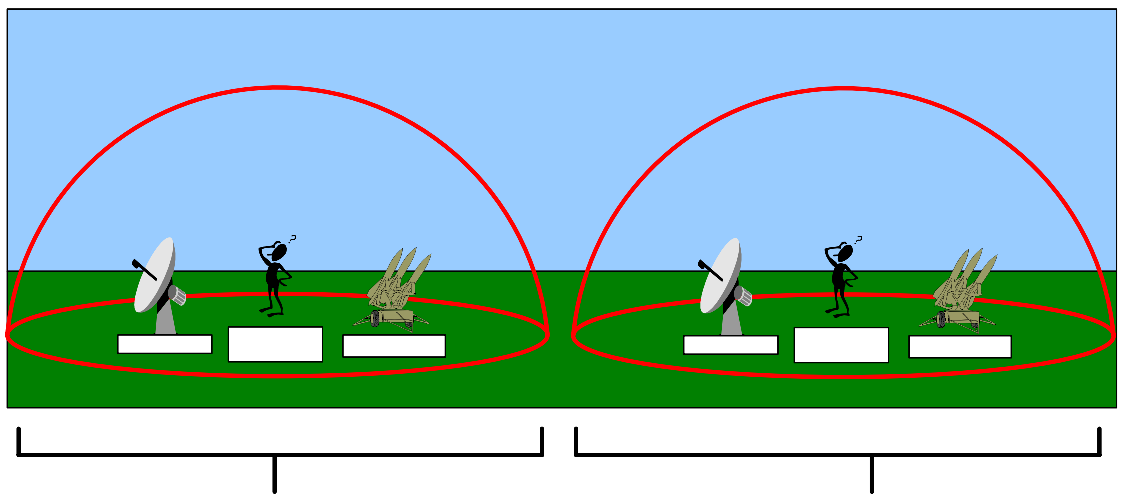

Figure 1. Non-integrated Air Defence System.

Figure 1 represents the non-integrated air defence system. The cells share the same mission statement but they all act independently of each other: Each sensor generates its own Air Picture and each decision maker acts independently when deciding whether an aircraft should be shot down. There is no rationalisation of 'local function' and the cells have no level of interoperability with each other – therefore, the system is not integrated.[16]

[16] It is worth noting that, using a broader definition of integration (that a group of components is integrated in some way if system-level design principles have been applied to their 'arrangement'), the first case may be considered integrated in a very basic way. This is because thought has been put into the geographic separation of the air defence cells so that they cover a given area. The system has a 'global function' of defending this larger area. However, for the purposes of this case study the

In the case of the integrated air defence system, a number of changes have been made:

- The individual cells are now interoperable with a central node (i.e. they have the ability to communicate with that node);
- The air pictures that are produced by each of the sensors are combined into a single Recognised Air Picture (RAP); and
- The function of decision-making has been centralised.

So, the individual air defence cells have been horizontally integrated and some of the local functions have been rationalised where there was obvious replication.[17] The rationalisation of the decision making function means that the integration is most likely permanent rather than transient – the individual cells can now no longer function independently without the reinstatement of the decision making function which, in practice, would be costly and time-consuming. Hence, the components of the integrated system are tightly coupled to the central node – there is significant effort involved in disintegrating them. The integration that has taken place is also restricted to the technical / physical domain and the implications of integration are discussed from a technical point of view. However, in reality there would be an associated organisational / social dimension to the integration (particularly since the function of decision making would most likely be performed by a human).

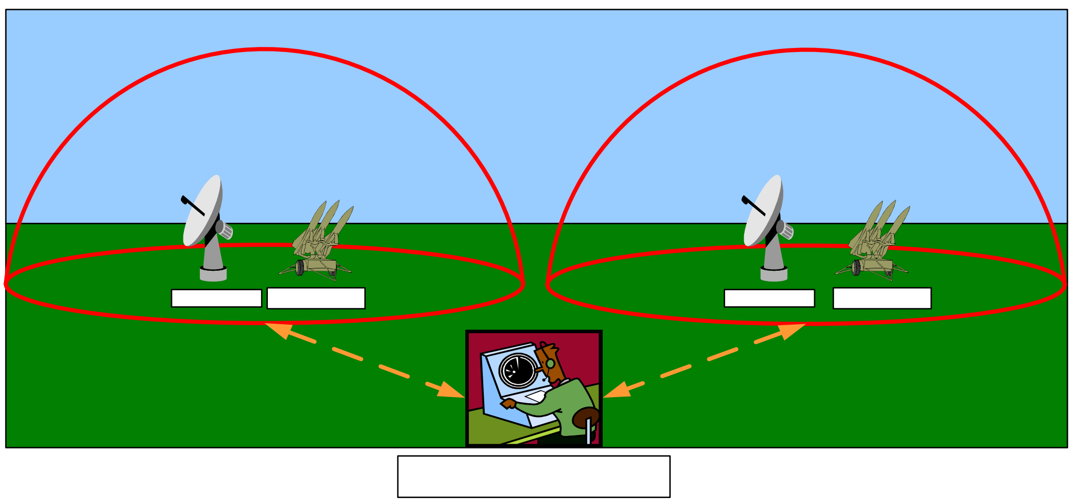

Figure 2. Integrated Air Defence System

It is necessary to ask the question: What is the designer of the system hoping to gain by integrating the air defence cells? On the face of it, both systems cover the same area and both would operate in a similar way. In terms of the values that are described in Section 1.2, air defence systems are typically integrated in order to realise

narrower definition of integration is the more appropriate one because domain experts inherently understand the comparison of integrated and non-integrated air defence.

[17] Horizontal rather than vertical integration applies because originally each cell produced a similar service (i.e. they were peers in terms of value chain position).

coordination of effort, improve the *efficiency* of the system and to exploit synergies (*integrate to innovate*).

Are these values illustrated by this simple case study? For example, is the integrated air defence system any more efficient than the non-integrated system? To answer these questions it is necessary to compare the way each system responds to a threat. In the non-integrated system each cell fires a missile if it believes it has detected a threat (with some probability associated with making a correct decision). If there is any overlap in the sensor coverage or if the threat traverses across multiple cells before being hit by a missile then it is likely that multiple missiles will be launched. The integrated system, on the other hand, is able to mount a coordinated response. Individual missiles could be launched against the threat. If the first missile misses the target then follow-up missiles could be launched. So, in terms of the response to a threat, the integrated system is able to use fewer resources to achieve the same effect i.e. it is more efficient.

At the level of fidelity that the two cases have been described it is not obvious how the designer would expect to realise synergies between the separate air defence cells. What aspect of the integrated system is greater than the sum of its parts? In reality one of the greatest advantages that an integrated air defence system has is the ability of the decision maker(s) to access a much more complete picture of the airspace. Access to the RAP means that decision makers are more likely to be able to identify threat aircraft based on their behaviour, primarily because that behaviour is visible across a much larger volume of airspace and for a much longer period of time. This represents a synergistic gain because the increase in effectiveness is greater than the sum of the effectiveness of the two individual cells.

Once the threat has been identified, the ability to mount a coordinated response also means that there is, potentially, a higher probability that the threat will be intercepted (e.g. the decision maker may choose to wait until the threat is in a more vulnerable position before launching the response). The ability to coordinate a response in this manner is due to increased centralised control, which is, in turn, enabled by tightly coupling the two air defence cells to a central node.

The risks associated with integration are, in this case, more difficult to assess. Robustness of the integrated system, as opposed to the non-integrated system, is perhaps the most obvious risk. Disabling the centralised decision making function would render the integrated system totally ineffective. However, the non-integrated system is still effective (albeit with reduced performance) if one of the cells is disabled thus demonstrating the *potential* for horizontal integration, where functions are rationalised, to reduce robustness.

In terms of attributes such as flexibility and agility it is useful to consider how each system might respond to an 'unforseen' situation. A threat aircraft may use a tactic of deception in order to appear as though it is a friendly commercial aircraft. A centralised decision maker relying on a RAP may be deceived and tag the aircraft track as 'friendly'. Once the track has been marked as friendly a change in its behaviour (such as a change of course towards a potential target) may go unnoticed. In comparison, the non-integrated system contains a diversity of views about what is happening in the airspace. It follows that while some decision makers may be deceived, other decision makers (i.e. those that are able to view the aircraft behaving as a threat) are not deceived and are able to mount a response. This example is not exhaustive (and there are obvious processes which could be put in place to avoid this situation) but it does illustrate the *potential* for integration to lead to a lack of diversity (in this case information diversity) which can, in turn, limit the agility of the system's response.

In practice, the level of integration that is applied to air defence systems may lie somewhere in between these two cases. Individual air defence cells would have access to a RAP, allowing for early warning of approaching threats. However, the cells would also have some level of autonomy in the decision making function – a combination which makes the most of the synergies associated with shared information while allowing some scope for flexible behaviour.

CONCLUSION & FUTURE WORK

Integration is an important concept within Defence, and it is increasingly being used in reference to capability. However, it has not been clearly defined—perhaps rightly so. This paper has attempted to answer two questions regarding integration: Why is it undertaken? What does it mean? The ideas contained herein are neither definitive nor complete, but they do form a basis for progressing thoughts on integration in a more structured and rigorous manner. The first question has been answered by providing a set of five values integration purports to support. These five values—control, coordination, expansion of scale/scope, efficiency and innovation—provide the context within which decisions about the process and particulars of integration might be discussed. Importantly, they focus integration decisions on the 'why' rather than on the 'what'.

The second question—what does integration mean—was answered not by offering an attempted definition, but instead by providing a framework of characteristics for discussing types of integration. By relating the characteristics to the values, it was possible to draw some lessons about integration. For example, integration does not come without cost. Pursuing a particular approach to integration means making sacrifices in some value areas. However, integration is not wholly incompatible with the general tenets of Network Centric Warfare or with the current emphasis on interoperability. Significantly, a core set of 'all-round' approaches to integration exists that provides adequate gains in a range of values.

This work is merely the beginning of our investigation into integration. The case study has provided some insight into the framework, but further development is needed to make sure that the framework is coherent and complete. The identified values provide a means for beginning the development of measures of effectiveness for integration. In turn, the characteristics of integration—the direction, degree of attachment, coupling and nature of the interactions—provide a first step towards measuring the degree to which a given system is 'integrated'. Is it important to know how 'integrated' a system is or should the focus be on how well the particular approach to integration is achieving the desired values? What are the best integration approaches for various elements of the Defence? How will they fit with the requirements of NCW and EBO? These questions remain. Future work will shed light on them.

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