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GBAeD 2030

A Concept for Ground-based Aerospace Defence in the Army-After-Next

by

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ABBREVIATIONS AND ACRONYMS

AAN	Army-After-Next
AD	air defence
ADF	Australian Defence Force
ADS	Air Defence System
ASAT	ground-based anti-satellite weapons
BOS	battlespace operating system
C2	command and control
CCOW	Contributions to Coalition Operations Worldwide
CSS	combat service support
DCA	defensive counter-air
GBAD	ground-based air defence
GBAeD	ground-based aerospace defence
IADS	integrated air-defence system
ISTAR	intelligence, surveillance, target acquisition and reconnaissance
MOLE	Manoeuvre Operations in the Littoral Environment
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RBP	recognised battlespace picture
ROE	rules of engagement
UAV	uninhabited aerial vehicles
UCAV	uninhabited combat aerial vehicles
US	United States

KEY DEFINITIONS

Aerospace Defence: Actions taken to defeat or neutralise hostile air and space activity.

Area Defence: Using GBAeD weapons to protect all units and installations within a defined space (usually measured in km^2).

Area of Interest: That area of concern to the commander, including the area of influence and areas adjacent thereto, and extending into enemy territory to the objectives of current or planned operations. The area of interest also includes areas occupied by forces that could jeopardise the mission accomplishment (such as enemy air bases and space systems).

Area of Influence: A geographical area wherein the commander is directly capable of influencing operations by manoeuvre or fire support systems generally under his or her control or command.

Area of Operations: That portion of an area of conflict necessary for military operations and the administration of such military operations.

Battle Management: Involves converting information on the tactical situation into decisions that meet the commander's intent.

Battlespace: Includes all aspects of the environment that are encompassed by the area of interest and area of influence. The battlespace also includes the operational environment (maritime, continental, aerospace, littoral, electromagnetic) and those relevant aspects of politics, culture, society, religion and economy.

Force Protection: Includes passive and active measures taken by the entire force to provide a commander with freedom of

action to achieve objectives by preventing the enemy, environment or other factors from interfering with other key functions of capability.

Freedom of Action: Freedom of action is achieved when the enemy cannot effectively counter friendly plans or actions.

Littoral: That area defined by the close proximity of land, sea and aerospace environments such that the operational effects of land, sea and aerospace power overlap.

Recognised Battlespace Picture: A correlated and identified representation of friendly, enemy and neutral activity within a defined segment of the battlespace.

Response Option: A subsystem that degrades the effectiveness of hostile aerospace vehicles. Options might include *active* responses that destroy or disable, such as missiles, lasers or guns; and *passive* options that fool, mislead, or protect, such as decoys, camouflage, hardening or mobility.

Sensor: A device that detects the presence of unusual objects. Sensors may be active (emitting energy to detect, for example radar), or passive (absorbing signature to detect, for example infrared).

ABSTRACT

This working paper proposes a concept for the Australian Army's Ground-based Aerospace Defence (GBAeD) system of 2030. GBAeD 2030 is part of a balanced joint force, and an integral element of the Australian Defence Force (ADF) air-defence system. It will be able to operate autonomously or as part of a coalition force. GBAeD 2030 will be important to achieving the future military roles, and have utility for tasks that do not require force.

Regardless of the operational task, GBAeD 2030 contributes to force protection by analysing aerospace activity, increasing situational awareness and defending key manoeuvre and strategic assets against hostile aerospace threats. These threats will include a range of uninhabited and inhabited aerial vehicles, helicopters, and cruise missiles. GBAeD 2030 will help to counter space surveillance by providing information on space-based information-gathering platforms and advice on countermeasures.

Acting as a system within the ADF Aerospace Defence System (ADS), GBAeD helps commanders to achieve freedom of action by:

- identifying aerospace activity within the battlespace;
- engaging hostile aerial targets that threaten the commander's freedom of action; and
- providing advice on measures to avoid the effects of hostile aerospace activity, including the impact of space-based reconnaissance.

Like today's force, GBAeD 2030 will be based on three subsystems: sensors, battle management and response options. However, GBAeD 2030 will be built with different priorities from those of today, the first being the requirement for a robust information subsystem. This priority recognises that information is essential to the ADF ADS, coalition airspace management, and to commanders that require a clear analysis of the aerospace situation. The system's robust nature comes from its ability to correlate information into a recognised battlespace picture through a battlespace management system. The system will also have a potent sting from its ability to employ the right type of response against assigned or threatening targets. These response options can plug into the system architecture at any time.

GBAeD 2030

A CONCEPT FOR GROUND–BASED AEROSPACE DEFENCE IN THE ARMY–AFTER–NEXT

INTRODUCTION

The task of securing Australia's national interests will remain central to government policy to 2030 and probably beyond. Success in this task will require the Army, as the Australian Defence Force's (ADF) land force, to fight in a range of geographic circumstances, particularly in littoral areas. The Army and other elements of the ADF might be committed to operations ranging from defending Australian territory to operations overseas with coalition partners and non-military agencies. The force will be required to subdue a variety of adversaries: from low-tech irregulars such as transnational criminals to advanced forces employing space systems, cyber-weapons and long-range missiles. The Government will, of course, expect strategic goals to be achieved at the lowest possible cost. Consequently, flexibility and force protection will be important to the future Army.

Plans to develop the future force will be influenced by a range of factors, including longer 'life spans'—which may exceed thirty years or more—for major weapon systems. These increased expectations mean that planners must develop capability that can accommodate legacy systems, grow with budget limitations, and evolve with technology. Long-range development plans must remain open to new ideas. Consequently, the Army is creating a conceptual 'Army-After-Next' (AAN), using 2030 as an indicative timeframe, to

provide a long-term planning tool for capability development.[1] This approach aims to break the 'equipment replacement' syndrome, allowing the Army to develop forces relevant to the future strategic environment. Experimentation, based on questions derived from AAN concepts, is essential to this approach.

Ground-based Aerospace Defence (GBAeD)[2] will be an important contributor to the AAN. This capability remains central to creating a balanced force because it uses information on the aerospace situation, and a wide range of response options, to assist with force protection and to help commanders achieve freedom of action. Developing a GBAeD force to achieve its likely future tasks requires significant changes to the air defence capability of the Army-in-Being.

This exploratory concept aims to describe the role and essential characteristics of GBAeD in the AAN. This working paper will:

- examine how technology, operational factors and the differences between asset types will influence the capacity of the future GBAeD force;
- outline the contribution that GBAeD could be expected to make to the military roles described in *Future Land Warfare 2030: Land Warfare Concepts* (FLW 2030);[3] and

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1 See Australian Army, *Land Warfare Doctrine 1: The Fundamentals of Land Warfare* (hereafter LWD 1), Commonwealth of Australia, Canberra, 2002, chap. 6.

2 Ground-based Aerospace Defence (GBAeD) is used in this paper to extend the current concept of Ground-based Air Defence (GBAD) to include consideration of space and missile defence issues.

3 Australian Army, *Future Land Warfare 2030: Land Warfare Concepts* (hereafter FLW 2030), Department of Defence, Canberra, http://rhntwp01.cbr.defence.gov.au/armyweb/Sites/DGFLW/docs/FLW2030, viewed 15 July 2001.

- describe a concept for GBAeD 2030, using the combat functions to outline the essential characteristics of the GBAeD system.

Annexes will also outline implications for joint capability development, the relationship between GBAeD and other battlespace operating systems (BOS), and the benefits and risks associated with this concept.

Assumptions. GBAeD 2030 is predicated on assumptions about:

- **Strategic policy.** Australia's strategic policy in 2030 will remain broadly consistent with Defence 2000, featuring a maritime approach to strategy, self-reliance in combat forces, a defensive posture, a close alliance with a still-powerful United States, and an emphasis on coalition operations.
- **Responsibility for aerospace defence development.** The Royal Australian Air Force (RAAF) will continue to lead aerospace defence developments, with the other services providing input based on their different needs.
- **Continued Relevance.** While offensive counter-air might remain the preferred option of achieving aerospace dominance, the defensive counter-air (DCA) mission will still be relevant. The future DCA system will include a ground-based component.
- **Responsibility for GBAeD.** The Army will remain as the capability manager of the future GBAeD system. This assumption could change if future concept development and experimentation showed that another organisation would perform this task better.

Utility. This concept provides a starting point for experimental work, particularly by raising issues and questions. On another level, the capability development community can use this

concept as a contribution to the discussion on the ADF's future aerospace defence requirements. Its utility as a future concept comes not from any revolutionary discovery of a better way of creating an air defence system (ADS), but from the way the concept outlines a vision for a system that is significantly better than the one Australia possesses today.

PART 1

INFLUENCES ON FUTURE GBAeD

Two dominant change drivers will influence the future GBAeD capability: technology and integrated operations. When these drivers are overlaid on each other they produce four scenario spaces that describe alternative futures for GBAeD. The drivers are, however, tempered by the wildcard of investment. In addition, the drivers and doctrinal preferences are changing the nature of the battlespace. Such changes will be highly influential in determining the type of assets that the GBAeD capability will need to defend in 2030.

The drivers produce four distinct scenario spaces (see Figure 1). This concept will focus on the best-case scenario for the GBAeD, which is produced by high integration, high technology, and optimal investment. Producing the 'balanced force' option is the best possible future for the GBAeD force because it will provide the type of flexibility that the ADF will require.

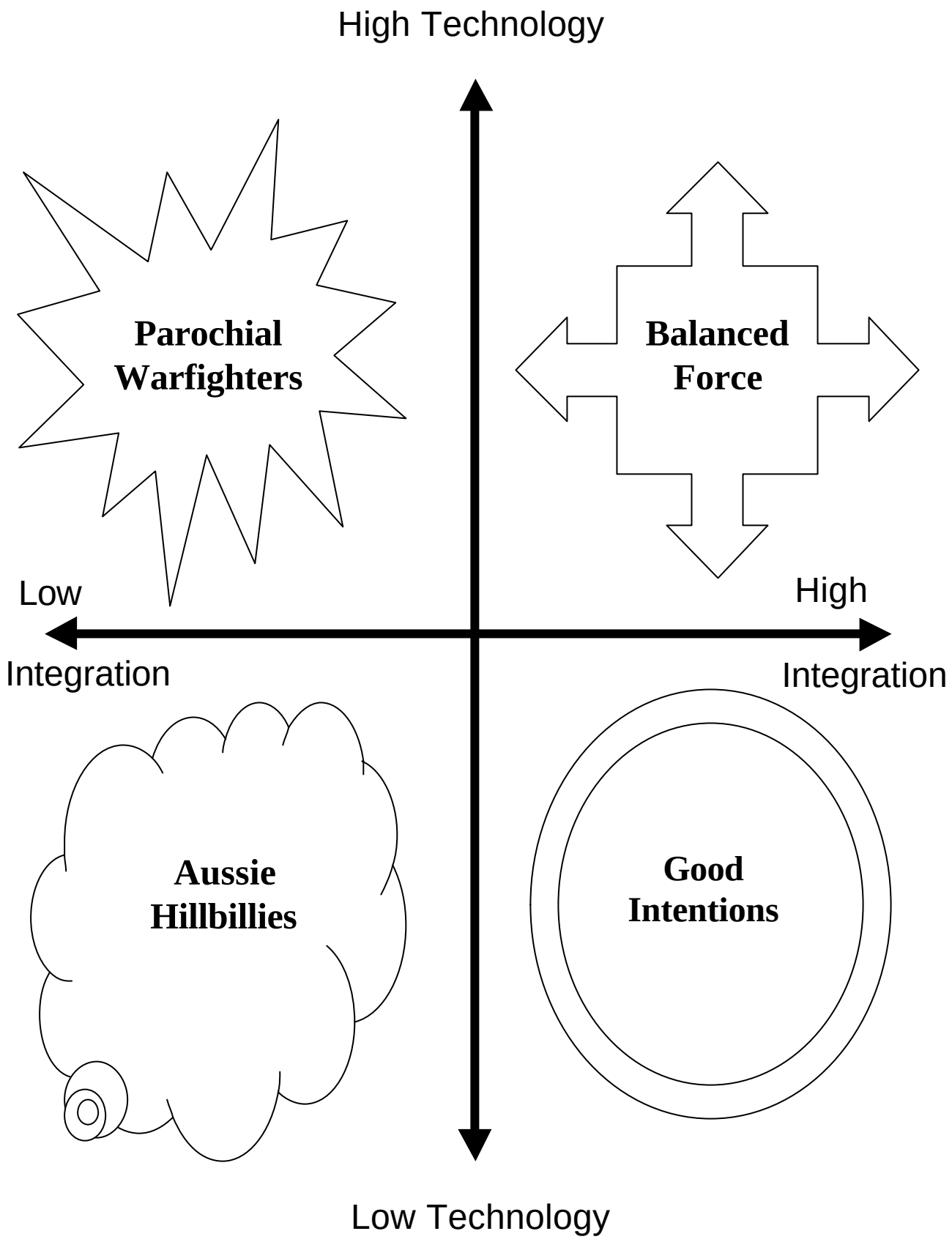

Figure 1: Alternative Futures for GBAD

PAROCHIAL WARFIGHTERS

The ground-based air defence (GBAD) force has embraced technology and is capable of a wide range of missions against the very best—as well as the most basic—foes. But each service has its own ADS. The high level of autonomy makes cooperation with other services difficult because of dissimilar procedures and communication standards. This parochialism inhibits flexibility and tempo.
Investment: Interservice rivalry produces fixed distributions of finances.

BALANCED FORCE

Australia produces a balanced, robust GBAD force that contributes to strategically relevant effects. GBAD can cope with a wide range of threats, from the very high tech to primitive missiles and aircraft. Information is dominant in this force: it moves seamlessly to the right people so that decisions are timely yet considered. Force protection extends from the international support base to the conflict battlespace. A systemic approach is taken to development. This approach tends to blur traditional organisational categories.
Investment: Optimal allocations.

AUSSIE HILLBILLIES

Army GBAD flounders against the basic opposition. GBAD is strategically immobile, and limited to engaging only basic (2000s) threats. GBAD is unable to cooperate with the other services or allies. Information is not passed beyond the originating unit and requires significant manual effort to exchange across organisational boundaries.
Investment: Minimal and ineffectual; dependent on Army's view of priorities.

GOOD INTENTIONS

GBAD is a small but balanced force that contributes to relevant strategic effects—up to a point. It is unable to engage high-technology threats, and its ability to cooperate with allies is hampered by separated and dissimilar systems. GBAD is available for only two to three priority assets. GBAD is essentially maintained to 'keep the art alive'.
Investment: Minimal, but made within the context of a balanced force.

Technology

The global priority on economic growth and improving people's quality of life through technological development will profoundly influence future warfare. For example, developments in micro- and nanotechnology—especially using robots that replicate biological forms—should help to make machines small and 'smarter'. Human performance could be improved by integrating computers into human functions. Information and communications technology should enhance system linkages, and be readily applied to improve command and control.

Importantly, commercial technologies will be adapted in novel ways, creating opportunities for 'non-state' actors to present asymmetric challenges to established powers.[4] Together, improvements in technology and unanticipated applications will influence aerospace technology, and their ground-based counter-systems.

Aerospace technology. By 2030, technology should improve the speed, agility, payload, protection and endurance of aerospace systems. Enabling technologies—including stealth, power, fuel, guidance, threat warning and systems integration—should contribute to these improvements. These improvements may have consequences including:

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[4] The issue of adaptation and the use of commercial technology was shown in a report claiming that US intelligence was concerned about Iraq's purchase of 4000 Sony Playstation II consoles because it was thought that the consoles could be adapted to program cruise missiles. See D. M. Gormley, *Dealing with the Threat of Cruise Missiles*, Adelphi Paper 339, International Institute for Strategic Studies, Oxford University Press, Oxford, 2001, p. 17.

- Pilotless vehicles, particularly guided missiles and uninhabited aerial vehicles (UAV), will probably increase numerically and have additional tasks in the battlespace; today's distinctions between pilotless vehicles and missiles might therefore become blurred. More actors will probably use capable and lethal cruise and ballistic missiles.
- Piloted aircraft will not disappear because cost and practicality will see these craft retained for some missions, particularly transport ones. In addition, passengers will generally tend to trust pilots ahead of computers.
- The military and commercial exploitation of space platforms will continue to improve communications and information gathering. Space platforms might also be able to designate targets. Space weapons could conceivably be deployed by 2030.
- More actors should use force multipliers, such as aerial refuelling and long-range targeting. Commercial systems could be adapted to enhance intelligence and logistics.

Technology will therefore increase aerospace system performance while also increasing the cost of generating a complete aerospace effect. This change should force most actors to consider the effects required to fulfil their strategy, and select capability to meet those needs. Actors with few resources or a motive to disguise their aerospace developments could choose to field only certain types of capability, such as missiles and UAV, while relying on commercial sources for some parts of their systems. Current GBAD missiles are unlikely to be able to cope with these new threats due to their relatively poor levels of performance and inability to acquire small targets.

GBAeD technology. Technology will also influence how aerospace threats are defeated. While today's dominant response options—missiles and guns—will still exist, technological advances (and perhaps social factors) will lead to more options:

- Less-than-lethal means such as dazzle weapons, and soft-kill methods such as microwaves, could disable aerial vehicles and prevent mission accomplishment.
- Directed energy will be available to disable aerial weapons, and might also be suitable for destroying hostile projectiles fired in large numbers.
- Sensor technology will continue to become more discriminating, and data movement will become faster and cheaper. Most sensors will be located away from associated weapons in order to improve coverage and survivability.
- Identifying a target with 100 per cent surety without alerting the target, and discerning real targets from decoys, will be high development priorities.
- Uninhabited combat aerial vehicles (UCAV) with air-to-air weapons could provide a cost-effective way of providing DCA missions.

The future GBAeD force could take many shapes and include a variety of sensors and weapon solutions. Experimentation should be used to determine the best mix of technology for the future GBAeD system.

Operations—How and Where

Integrated Operations. By 2030 'integrated operations' should replace joint operations as the ADF's *modus operandi.* In integrated operations, national planners must apply every available military and civilian asset, as well as that of coalition partners, in a manner that allows each element to create effects that complement others. Integrated operations will require military and non-military components to understand how each contributes to strategic aims. This approach to operations will require a new doctrinal basis, and the ability of different agencies to harmonise with each other.

Operations in the littoral. Current strategic guidance requires an ADF that is capable of fighting in littoral areas, either alone or as part of a coalition. This requirement will probably remain valid out to 2030 because the relative importance of coastal areas appears to be increasing. One consequence of this trend is a higher number of coastal (and potentially island) mega-cities across the world, including in the Asia-Pacific region.[5] Exerting control over the people and infrastructure of these cities will be essential to prevailing in any conflict. The confluence of urban land areas with the maritime and aerospace environments makes targeting and identification more difficult, placing an added pressure on target discrimination and proportional responses. The littoral's complex terrain will also restrict engagement ranges in some circumstances.

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[5] The terrain of most islands in Australia's immediate region will basically consist of such cities, farmland, and mountainous jungle.

Wildcard

One wildcard that will influence the future force is investment. Capability development will require a substantial commitment of resources over a long period of time. Research and development is an essential contributor to capability development, and also a significant cost. Consequently, investment in the future GBAeD capability will be required soon if it is to realise a functioning and relevant capability by 2030.

Asset Vulnerability

Forces in either the conflict or sanctuary battlespaces,[6] and strategic assets on Australian territory, will typically have different characteristics and vulnerabilities. Consequently, different enemy aerospace systems will be used to target these assets.[7]

- **Units in the conflict battlespace** will tend to be mobile, small (offering only a portion of themselves to attack at any time), dispersed, and protected to varying degrees. Some units may be armoured. Where the threat exists, responsive aerospace weapons—such as helicopters, close air support, UAV, tactical missiles and artillery—may be used against them.

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6 The conflict battlespace is established by the manoeuvre force to conduct combat operations. The sanctuary battlespace supports the manoeuvre force by holding units, fire support and logistics that are not immediately required to achieve the mission. See FLW 2030.

7 This typology has been developed from an unpublished paper by P. J. Hutchings and N. J. Street, 'Future Short Range Ground Based Air Defence: system drivers, characteristics and architectures', Defence Evaluation and Research Agency, Malvern, UK, 2000, p. 4. This typology does not preclude assets from being targeted by ground forces or information attacks.

Some attackers could use mass or swarm tactics to overwhelm defences, while others will rely on precision strikes.

- **Units in the sanctuary battlespace and strategic assets** will tend to be larger, dispersed, static or mapped and possess a low degree of combat power. They may be 'fortified' or hardened, but are often unprotected. They will usually be attacked by small numbers of fixed-wing aircraft, cruise or ballistic missiles, and strategic UAV.

Implications for GBAeD 2030

Technology, operational factors and asset vulnerability might change the political and military expectations of GBAeD 2030. These expectations will arise from a number of push-and-pull factors—such as the ability of technology to deliver new solutions—in the type of threat that might be encountered, and in the ability of GBAeD to engage new types of aerospace targets. Also, the influence of information might pull GBAeD operations in a new way, while the increasing role of space might also push GBAeD development in new directions.

Advances in technology and the wide availability of new technology mean that GBAeD will need to defeat threats such as advanced fighters and guided missiles, as well as improvised ones such as explosive-laden UAV. Technology may also become so widely available that state and non-state actors will be able to generate aerospace effects by obtaining services and 'dual use' technologies—such as imagery, intelligence and logistic support—from commercial sources. Consequently, an aerospace threat to ADF operations could develop unexpectedly and include high-tech elements.

Technology might raise social and political expectations for ‘bloodless’ conflict. On the one hand, the availability of ‘soft kill’ technology might provide non-lethal options for political decision-makers. Society might also see ‘total’ force protection as the first goal of a military operation. The idea of total force protection may create problems for military decision-makers when they have to choose between allocating scarce firepower resources. Should commanders defend a key bridge or supply dump from air attack, or should they use the available weapons to protect people? On the other hand, new directed-energy weapons might prove capable of engaging hostile artillery in flight, and so create a new expectation for GBAeD as a new counter-battery asset.

Information that assists identification, provides an understanding of enemy intentions and gives timely warning of impending enemy activity will be essential to achieving freedom of action. The availability of such information might give commanders the ability to outmanoeuvre opponents by changing routes, showing or hiding forces, or suddenly changing the course of action to avoid the enemy’s actions. The GBAeD system must be one source of this information.

The increased abilities of threat systems will also render GBAeD systems more vulnerable to attack, making passive sensing and the displacement of sensors and weapons priorities for survival. In addition, non-cooperative target recognition—again, preferably passive—will be essential to allowing permissive rules of engagement (ROE).

GBAeD will be expected to operate with coalition partners and non-military agencies in integrated operations. It may also be expected to use its information systems, and possibly appropriate response options, in non-conflict operations. The probability that

GBAeD will be used offshore, particularly in littoral environments, means that GBAeD will need to be strategically mobile, and be able to operate effectively in complex terrain.

Assets in the conflict and sanctuary battlespaces will clearly require different weapons to protect them from attack: rapid-firing, highly mobile weapons will be needed in the conflict battlespace; and longer range, higher altitude and possibly anti-ballistic missile weapons in the sanctuary battlespace. The best GBAeD system, which also represents the best value for money, will ensure high degrees of commonality between forces tailored for these requirements.

PART 2

GBAeD's CONTRIBUTION TO MILITARY ROLES

FLW 2030 describes three military roles for the ADF: Homeland Defence, Manoeuvre Operations in the Littoral Environment (MOLE) and Contributions to Coalition Operations Worldwide (CCOW). Each military role will place slightly different demands on the system: in terms of defended asset, supporting infrastructure, geography and threat.[8] This part will examine the capabilities and options that the Government and the ADF could expect GBAeD 2030 to contribute to each military role, starting with the ADF's primary task of Homeland Defence. The part will conclude by discussing the implications of the military roles for GBAeD 2030.

Homeland Defence

The challenges involved in defending Australia in 2030 will still be similar to those of today: vast distances, a hostile climate and dispersed assets will probably remain constant features. Advances in intelligence, targeting, and weapon systems will, however, improve attack capabilities and give adversaries a spectrum of options—ranging from force-on-

[8] The key functions of capability are those functions that a military force must be capable of performing in order to generate military power (as an element of national power). The key functions are manifest at the strategic level. The key function of force protection includes the passive and active measures taken by the entire force to provide a commander with freedom of action to achieve strategic objectives. Force protection therefore involves preventing the enemy, environment or other influences from interfering with the other key functions.

force operations to asymmetric attack—to use against Australia. For example, an air attack launched against Darwin from somewhere in the northern archipelago would constitute a high-end threat to Australia, while an explosive-laden UAV flown into a politically significant building in Sydney would constitute a more asymmetric application of aerospace power. Regardless of the type of threat, the political and military leadership must be assured that hostile action against the Australian homeland could not easily undermine the nation's will. Homeland Defence 'encompasses the range of pre-dominantly preventative and reactive military and civil measures required to *deny* adversarial strategic outcomes within Australian territory, seas and economic zones'.[9] Figure 2 shows the operational tasks of Homeland Defence. GBAeD could contribute to six of the nine tasks shown in Figure 2: defeating incursions onto the mainland or offshore territories, missile defence, protecting civilian infrastructure and ADF facilities, and protecting sovereignty.

Defeating Incursions

While outright invasion of Australia in the period 2010 to 2030 is unlikely, smaller-scale incursions onto Australia's mainland or territories are possible. Incursions from air and space might become even more likely as the performance and proliferation of advanced inhabited aircraft, air-to-air refuelling, satellites and UAV increase. Regardless of the scale of the incursion,

[9] FLW 2030. In military tasks, the ADF is the lead agency. In civil tasks, the ADF provides support to the civil power until such a time as the use of military force is authorised to resolve an issue.

government policy states that the ADF must be capable of defending Australia without combat support from allies.[10]

Defeating any incursion onto the Australian mainland or an offshore territory will be a whole-of-nation responsibility, based on the concept of integrated operations. GBAeD 2030 could be expected to contribute to defeating incursions by deterring hostile aerospace activity and sector air defence, while providing advice on space-based incursions is a potential role. Another important function, protecting combined-arms manoeuvre forces, will be discussed later.

Deterrence. To function as part of an effective national deterrent, GBAeD 2030 must be considered—by potential rivals—as an integral part of the national defensive posture. Ensuring that the GBAeD 2030 is strategically mobile; tactically, technically and logistically prepared; and has a reputation for being an effective fighting organisation will help deterrence. Another positive aspect of GBAeD's deterrent effect will be its ability to deploy without escalating a conflict. For example, the pre-emptive deployment of GBAeD to an offshore territory during a tense period could demonstrate resolve while being less provocative and logistically simpler than deploying multi-role fighter aircraft or ships.

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[10] Australia's current policy concerning this is explained in the Department of Defence publication entitled *Defence 2000—Our Future Defence Force*, Defence Publishing Service, Canberra, 2000, p. 46.

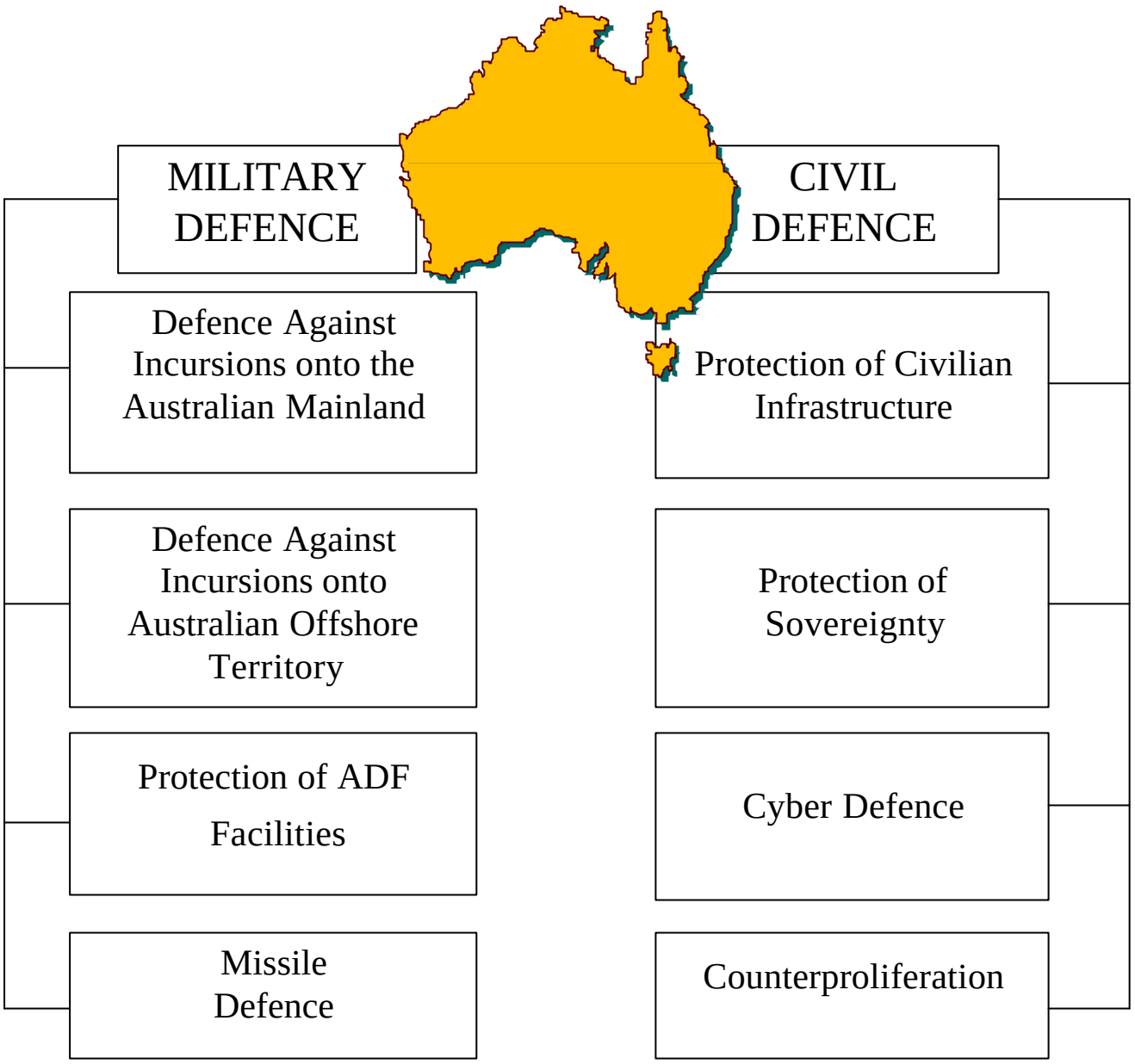

Figure 2: Homeland Defence—Military and Civil Tasks[11]

[11] This diagram has been sourced from FLW 2030, chap. 5.

Sector air defence. This function—which includes detecting, identifying, controlling and intercepting incursions into Australian airspace—will provide the backbone of Australia's air and aerospace defences. The ADF ADS[12] has already been established to deter and defeat air threats; it will be developed and refined out to 2030.[13] The Army will be expected to contribute, through GBAeD units, to the ADF ADS on many levels. In the sensor and battle command subsystems, Army GBAeD units will be required to provide information on their local aerospace situation to the ADF ADS, and provide advice on Army operations to the Joint Force Air Component Commander. GBAeD will also provide response options to a layered ADS.

Space-based 'incursions'. Such 'incursions', using commercial and specialised satellites, will always be possible—and legal. Space systems have the potential to provide states and other groups with a pervasive level of situational awareness, and improve their early-warning and targeting capabilities. Technology such as radar imaging may

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[12] The ADF ADS is a joint and national system, consisting of:
- a range of sensors such as over-the-horizon radar, RAAF control units, RAN anti-air warfare radar, Army ground-based radar and civilian air traffic control;
- response options including air defence fighters, RAN surface-to-air missiles, and Army ground-based missiles;
- Commander Australian Theatre's command-and-control system, which may be divided in joint force operation areas (sectors); and
- a logistic system to sustain operations.

[13] Current RAAF Projects, including AIR 6000 and Project Wedgetail (Airborne Early Warning and Control) will determine some elements of the future system within the next five to ten years. These platforms—and their resultant capabilities—should still be in service in 2030.

overcome the present inability of satellites to ‘see’ through buildings or canopy. The sheer number of networked satellites should be sufficient to ensure coverage most of the time. Consequently, the ADF must consider both active and passive means to counter satellite reconnaissance and surveillance. GBAeD could be expected to provide advice on this threat so that commanders and their staff understand the coverage of satellite surveillance and the options available to counter the threat. Active options such as ground-based anti-satellite weapons (ASAT) might also be considered for the future GBAeD system. However, starting a program to achieve space control would require a very significant political decision, as well as significant resources.

Missile Defence

Preparing Australia for missile defence will require another significant political decision. Missile defence refers to active measures to defeat hostile cruise or ballistic missiles in flight. While ballistic missiles receive the most international attention, weapons such as these will remain expensive and difficult to produce for most states. The real ‘sleeper’ issue is cruise missile defence, because even non-state actors could make relatively cheap ‘cruise’ missiles from converted UAVs.

Cruise-missile defence. Since the debate about cruise missiles is less politically charged, more states could acquire this technology without the same level of scrutiny that ballistic missiles attract. While preventing cruise missile proliferation is the best defence, the most practical solution will involve coupling the necessary sensors to detect all aerial vehicles to a range of active (including soft kill) and passive responses. The soundest way to defeat the cruise threat will probably be to track the incoming missile from above, and attack it with a

faster and more agile missile. Other options, including soft kill, and close defence weapons (to attack the missile 'head on') might also be effective.

Ballistic-missile defence. This type of defence cannot be ignored because numerous regional and global actors currently have ballistic missile programs, while others could acquire them by 2030. Of the plans to develop countermeasures, the United States (US) system is likely to be the most credible and effective by 2030.[14] This plan may consist of systems that either engage missiles in their boost phase, during flight (by space-based weapons) or as they begin their re-entry into the earth's atmosphere. It envisages destructive methods such as kinetic vehicles and even lasers. The system will also require a sophisticated, near-global coverage and a fast early-warning system to identify launches. Australia might choose to develop part of a missile defence system when anti-air warfare destroyers are purchased around 2010, but the resources and skill to develop an independent missile-defence system will most probably remain beyond Australia's reach.

Protecting ADF Facilities and Civilian Infrastructure

The protection of fixed military and civilian assets from aerospace attack is a key civil and military task in Homeland Defence. Military and civil assets are likely to be large, relatively static installations. These assets will be targeted by space-based reconnaissance, and attacked by long-range platforms and missiles. They will not be confined to south-eastern Australia.

While defending civilian and military assets will have many similarities to defeating incursions, the large number of assets

[14] A portion of the system may be functioning by 2004.

to be defended means that only the highest priority assets will receive active GBAeD coverage. Consequently, passive means, including redundancy and decoys, will be the most likely way of protecting the remainder of the assets. If an active measure is needed, a form of soft kill—such as electronic disruption—might be a practical countermeasure.

Protecting Sovereignty

The final Homeland Defence task considered in this part is the protection of national sovereignty from essentially criminal threats. GBAeD 2030 could be required to help with this (primarily civilian) task. By 2030 Australian sovereignty could be threatened by transnational criminals, such as smugglers, who use aircraft as their vehicle-of-choice for illegal cargoes. GBAeD 2030 could be expected to help detect the movements of these criminals through their information system and report such movements to civil authorities. In some very limited and extreme cases, the government could authorise the use of GBAeD weapons to engage aircraft smuggling non-human cargoes. This option might not be so extreme or unpalatable if criminals were to use UAV.

Using GBAeD in this way would require a highly responsive command, control and intelligence system. GBAeD would need to be deployed preemptively, possibly without its response options. The active defence of Australian sovereignty would require foolproof identification methods, unambiguous ROE (ideally positive control), and legislation in order to make an active GBAeD response viable.

Manoeuvre Operations in the Littoral Environment

This section outlines the capabilities that GBAeD 2030 could be expected to contribute to the second military role of MOLE. Such operations are characterised by 'land forces, operating as part of a joint task force, that conduct air or sea entry operations in combat formations in Australia's immediate neighbourhood'.[15] These operations will involve special and conventional forces, with the latter formed into combined-arms teams. Commanders must always be prepared to protect, or shield, their strengths from enemy aerospace interference through active measures, or by passive measures such as movement, hardening, deception, or dispersal.

GBAeD in MOLE

GBAeD could be required to contribute to each of MOLE's four actions:

- During shaping actions, GBAeD could help to deter an enemy from striking at sanctuaries, and provide the commander with information on the aerospace situation around those sanctuaries. Effective GBAeD might degrade enemy aerospace power, deny information to the enemy by preventing reconnaissance flights or provide information on satellite coverage. This action should contribute to joint efforts to dominate the aerospace environment. GBAeD 2030 might also be required to help with deception actions by signalling their presence, or creating a false signature.

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15 Australian Army, *Concept for Manoeuvre Operations in the Littoral Environment (MOLE)*, Commonwealth of Australia, Canberra, 2001, p. 5.

- During entry from the air and sea, GBAeD 2030 would be required to establish information coverage of critical areas and provide response options to disrupt an aerial counterattack. GBAeD might be needed to cover critical landward gaps in the force's aerospace defence during deployment, particularly if landforms interfere with sea-based coverage, and if the objective area is beyond the range of RAAF land-based air surveillance and strike assets. GBAeD will need to be light enough to enter with the main force, and to sustain itself at an appropriate level of intensity. Early-entry forces will also require information on the area's aerospace situation and GBAeD protection.

- During decisive actions, such as strikes or evacuations, GBAeD will be required to help commanders to achieve freedom of action by providing an accurate understanding of the aerospace situation, and response options to prevent hostile aerial vehicles from interfering with the commander's plan. Protecting the main effort, and essential supporting elements of that effort, will be the critical task for GBAeD. During this phase GBAeD will be an integral part of the combined-arms team, and will need commensurate levels of protection and mobility.

- During transition actions, which might include stability operations,[16] GBAeD 2030 will help to dominate the area of

[16] Stability operations will usually require the ability to conduct operations in urban areas. The transition will also probably involve handing over responsibility for the operation to more appropriate forces. See A. V. Balmaks, 'Control Operations—A New Warfighting Paradigm for Military Operations in Urban Terrain', *Land Warfare Conference 2000 Papers*, Combined Arms Training

operations by increasing battlespace awareness. GBAeD may also help to deter further hostility. GBAeD may be required to work with airspace users from the host nation, non-military mission elements and neutrals, and to help protect the force during redeployment.

GBAeD 2030 and the Combined-arms Team

In order to 'shield' the combined-arms team from enemy action,[17] GBAeD 2030 will be required to provide the team with information from networked sensors, response options, and staff who can advise on measures to reduce the aerospace threat. This information will help to improve the force's situational awareness. Conversely, even a relatively unsophisticated enemy could use aerospace power to threaten the security and deception plans of the combined-arms team unless GBAeD information and protection is available.

Early-entry forces, such as light infantry and special forces, will require GBAeD sensors and weapons that do not restrict their mobility. Portable weapons, supported by an uncomplicated battle-management subsystem, would best fulfil this need. Information on the aerospace environment would be required, using equipment tailored to the force's ability to carry and maintain that equipment. This equipment might include lightweight place-and-forget sensors, small portable systems (for light infantry) and space-based sensors.

Mounted and mechanised combined-arms teams could be supported by specialist GBAeD vehicles, which should be air-portable in strategic-lift aircraft and helicopters. Specialist

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and Development Centre, Department of Defence, Melbourne, 2000, p. 49.

17 See LWD 1, chap. 4.

GBAeD weapons should focus on area defence to assist manoeuvre. Vehicle defensive aid suites, and perhaps main armaments, in fighting vehicles should include weapons (either hard or soft kill) to supplement specialist GBAeD weapons. When designing such an additional capacity within the combined-arms team, force developers must consider situational awareness issues such as identification and fire discipline, because vehicle crews will require the same information as specialist GBAeD weapons.

Contributions to Coalition Operations Worldwide

The military role of CCOW 'encompasses the commitment of ADF expeditionary forces to coalition operations in which the adversary does not threaten Australia and deployment to the theatre of operations is undertaken administratively'.[18] CCOW is likely to involve many types of military situations, including conventional warfighting, peace operations, humanitarian operations, and non-military support tasks that might not involve force. GBAeD 2030 will also be required to fight against the broadest possible range of threats, including some that might not be present in the Asia-Pacific region. The broad requirements of GBAeD 2030 for CCOW will be examined through two possible tasks: coalition warfighting and peace enforcement operations.

Coalition Warfighting

Australia's current preference for coalition warfare is likely to continue due to its political attractiveness and the small size of the ADF. Coalition warfighting could take place in any type of

[18] FLW 2030.

conflict, from counterinsurgency-style operations through to international war.

One example of coalition warfighting could involve Australian participation in a US-led force. In such a contingency, the United States would probably provide the bulk of the aerospace capability, including space-based and terrestrial intelligence support, logistic support, and most of the aerospace combat effort. The United States would probably also provide ballistic missile defence, as well as higher-altitude and wide-area aerospace defence.

To be a credible part of a US-led coalition, any national contribution would need to provide close-in GBAeD weapons to protect its own manoeuvre forces. Without some GBAeD protection, any contribution would be vulnerable to an aerospace threat and therefore a liability. The United States would also demand a capability to identify aircraft that was at least the equal of their own. Without this capability the contributing GBAeD force would be placed under highly restrictive ROE.

The likely predominance of US forces in theatre means that developing an autonomous sensor network might not be a particularly high priority. Also, any long-range sensors might be deployed as part of a coalition sensor network. This makes interoperable communications essential to coalitions.

Of course, the United States might not lead every coalition, and the assumption of US military predominance might be flawed. If this were the case, interoperability in a ‘global’ coalition might be preferable, but also more difficult to develop because a single standard might not be easily definable. Developing an autonomous GBAeD system would

therefore have some advantages, since such a system could be guaranteed to be robust and complete.

Given the likelihood of casualties in these operations, failing to provide adequate protection for manoeuvre forces might create political risks, particularly if the public was sensitive to casualties. GBAeD 2030 will be an important capability that can help to mitigate that risk.

Peace Enforcement Missions

In situations where one party must be coerced into accepting peace conditions that are supported by the international community, a peace enforcement mission will generally be needed. Violence can be expected due to the lack of consent. However, because of the nature of such missions, the domestic public will probably be unwilling to accept major casualties or tolerate extensive damage to civilian infrastructure. In other words, the Australian public is unlikely to tolerate a peace mission that harms the people with whose welfare the ADF has been entrusted, or in which there is a loss of Australian lives. This paradox makes peace enforcement missions among the most complex of all missions.

GBAeD 2030 would be required to monitor and enforce no-fly zones, and provide evidence of aerial activity for subsequent investigations. The deployment of GBAeD in these situations may also deter rival parties from continuing operations by dominating the aerospace environment and providing evidence of resolve. Challenges in relation to aerial vehicle identification will remain, while the penalties for incorrectly identifying and engaging targets—in terms of moral authority and legitimacy—will be far higher than those in warfighting operations.

In addition, the strategic cost of casualties or damage to major platforms will far outweigh the tactical effect of the loss.

Implications of Military Roles for GBAeD 2030

This section will outline the implications of each military role for GBAeD 2030, and discuss the need for an autonomous GBAeD system.

While each military role places different demands on the GBAeD system, developing a different system for each role would be wasteful and unnecessary. Instead, it would be preferable to base decisions about the future force on the priority of each role. Decisions should aim to create a system that can adapt to different environments, threats and command-and-control systems. Achieving this level of adaptability places a premium on similar sensor and battle management subsystems, but does not preclude different response options for different circumstances.

GBAeD 2030 in Homeland Defence

The flexibility of GBAeD 2030 in Homeland Defence is shown by the way it can produce a wide variety of effects, ranging from non-aggressive responses, through to providing information on parties that breach Australia's sovereignty, to lethal action that protects Australian assets and lives.

Space control and missile defence are relatively unexplored issues in Australia, and warrant further study. Given that many future aerial vehicles will resemble cruise missiles in some degree, the GBAeD system must be capable of defeating that threat without assistance from other countries. This concept also assumes that Australia could only develop parts (at most) of a ballistic missile defence system, for example, by

incorporating a theatre missile defence system into a future anti-air warfare ship.

At present, the size of the GBAD force for ‘defence of Australia’ is based on historical and budgetary factors that have limited the size of the force to two batteries. By 2030, a more rational approach to GBAeD force planning—based on needs, not compromise—must be in place, preferably using an appreciation of the number and types of assets that require protection and the possible threat. Given that active GBAeD will never be available to protect all civilian and military assets, investment in decoys or soft-kill methods will be important.

GBAeD 2030 in MOLE and CCOW

The preceding discussion of MOLE and CCOW raised issues concerning the physical environment, mobility, command and control, integration, and coalition operations. In general, these military roles require a GBAeD system that is highly mobile, and able to operate both autonomously and with coalition partners.

Physical Environment. The physical environment of MOLE will be extremely demanding for aerospace defence. Firstly, the distance from home bases places an emphasis on strategic mobility and creates significant challenges for logistics (particularly repair). The combination of islands, urban areas and steep jungle-covered landforms in many regions will restrict the performance of line-of-sight weapon and mast-mounted sensor systems. While, by 2030, technological advances will have largely negated the current impact of night and day on operations, the influence of weather on MOLE may not be as easily overcome. This is especially true for the monsoon and cyclonic weather patterns experienced throughout maritime South-East Asia and the South Pacific.

The GBAeD system must therefore be designed to suffer only minimal degradation in extreme weather and rapidly return to full operational status after storms.

Mobility. The system must be strategically mobile in both transport aircraft and shipping, and be fully functional soon after disembarkation. Tactical mobility will be an essential feature of the system since it must be able to keep pace with the supported formations.

Command and Control. The integrated air defence system (IADS) provides the conceptual basis for GBAeD 2030 command and control (C2). In this system, all sensor and response options are controlled centrally by an AD commander who is responsible to the joint force commander.[19] Similarly, while the central agency will also control the fire of all GBAeD weapons, including nonspecialised surface-to-air weapons, the manoeuvre commander will have the ability to assume control of any asset assigned to him if the centralised system is disrupted. The main issues relating to C2 include:

- **Identification.** While the identification of air traffic is difficult under the best conditions, terrain, political considerations and the presence of similar and dissimilar aerial vehicle types all combine to make identification difficult in MOLE and CCOW.
  - The presence of aerial vehicles belonging to neutrals, civilians, several different national forces, government and non-government agencies poses a significant

[19] 'Control' is defined as 'a service provided to increase combat effectiveness by promoting the safe, efficient and flexible use of airspace' (ADFP 13, para. 202). A central authority that issues positive and procedural airspace control measures discharges this responsibility.

identification challenge, especially where actors use similar military platforms, or where commercial platforms are also used for military purposes.

  - Since destroying the wrong aircraft could have strategic repercussions, stringent identification standards would be applied in all circumstances. Also, ROE will ensure that decision-makers are held accountable. The desire of our forces to avoid destroying the wrong aircraft will require the aerospace defence system to ensure that the right aircraft has been identified, preferably by using multiple identification methods. The developing requirement for accountability and transparency in military activity will necessitate a means to capture data involved in engagement decisions.

- **Communications.** The physical environment, enemy action and presence of coalition partners will influence communications requirements. The communications systems will need sufficient interoperability to allow the passage of voice and data, particularly that relating to the recognised battlespace picture (RBP). The enemy is likely to target communications in an attempt to disrupt friendly operations. GBAeD 2030 must be designed in such a way that breaking the ADF ADS communication links does not make the system ineffective. These types of communication requirements begin to build a case for developing an autonomous GBAeD system.

- **Increased connectivity.** The Army will be structured and equipped as an interconnected complex of sensors and

actors in a sensor–actor architecture.[20] In MOLE, connectivity will rely heavily on satellite communications and commercial information bearers. Connectivity with joint assets, and coalition partners, is essential.

- **Redundancy.** If centralised information is a key strength of the GBAeD system, then command nodes must not present any vulnerability. It is essential to develop alternative operation centres, without losing connections or information.

- **Liaison.** GBAeD 2030 will require liaison parties to facilitate operations, pass information and provide advice to partners, including airborne early-warning and control units, ground units and headquarters of ADF and coalition AD forces.

Integration of all weapons. The combined-arms team of 2030 should include a variety of weapons that could engage aerial vehicles. Integrating each capable weapon into the ADF ADS will rely on widely disseminated information about the aerospace battle and the ability to exercise real-time control over engagements. Control of friendly aerial vehicles will be essential to preventing fratricide, while information on threats will assist decisions to avoid or engage targets. Cooperative engagement capabilities with joint and coalition forces would also increase GBAeD effectiveness.

Coalition operations. Army's GBAeD development should keep 'one eye' on similar developments in the United States, and as a minimum, the Army's GBAeD should be able to 'plug and fight' into a US-controlled architecture. Creating the ability to 'plug and fight' would require:

- common identification standards and procedures;

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[20] See LWD 1, chap. 2.

- the ability to pass data between battle management centres, or directly from sensors to the battle management centre of a coalition partner;
- sufficient organic response options to provide protection against the full range of threats (excluding ASAT, tactical or long-range ballistic missiles); and
- doctrine and concept development that considers ideas and changes in US forces.

It might also be desirable to develop compatible sensors, battle management procedures and response systems.

Autonomous GBAeD

GBAeD 2030 should make its contribution to the military roles as part of the ADF ADS or coalition force IADS. A number of factors might, however, prevent the wider systems from operating effectively, or reduce the ability of these systems to protect forces from hostile aerospace activity. By way of example, these limitations could arise from:

- **Range factors.** The operation may be conducted outside Australian-based radar coverage, or too far away from land bases for airborne early-warning and air-superiority fighters to maintain a continuous presence.[21]

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[21] This judgment explicitly assumes that the RAAF will be less able to provide land-based air cover to operations that are far from their land bases, and that naval-based air-defence systems will remain less than optimal over land. The contemporary implications of these issues are discussed in D. K. Connery, 'Ground Based Air Defence in the Amphibious Tactical Lodgment', in *Australian Defence Force Journal*, July–August 1998, pp. 19–30.

- **Forward-base requirements.** Under some circumstances, refuelled fighters and early-warning aircraft might not be able to reach the battlespace without forward bases. Given the small number of suitable bases in most South Pacific states, planners might not be able to count on seizing a base and might therefore encounter a critical operational shortfall. GBAeD may provide part of the solution to such a shortfall.

- **Weather patterns.** Tropical weather patterns will be experienced in MOLE. Under these conditions, it might be possible for the enemy to resume offensive air operations after a storm faster than the RAAF/Coalition forces that have returned to distant bases to avoid the storm. Consequently, there may be a period of time when land forces in the battlespace will have no friendly air cover and will have to fight alone.

- **Enemy action.** Enemy action could disrupt the ADF ADS, leaving individual components to fight for themselves.

Consequently, GBAeD 2030 may need to operate outside the ADF ADS—that is, autonomously—and the likelihood of GBAeD 2030's operating outside the ADF ADS will increase as the distance from the operational area grows. To be autonomous, GBAeD 2030 must identify and fuse local information, as well as incorporate information from other networks to form a RBP.[22] GBAeD 2030 will also need its own battle management system, which should be capable of controlling weapons from other systems. Autonomy will be essential to creating a flexible system, and to ensuring that the

[22] The potential for one vehicle to use air, ground and water as mediums will blur the distinction between environments, and make a recognised battlespace picture essential to operations.

ground-force commander can be certain of protection from aerospace threats.

Summary: Broad requirements of GBAeD 2030

The most important implication of this section is the importance of developing a GBAeD system that can adapt to different geographical, warfighting and partnership requirements. To achieve this level of adaptability, GBAeD 2030 will need to:

- provide the commander with a significant advantage, particularly in the aerospace dimension of the battlespace. This advantage will be based on information and effective response options;
- defeat cruise missiles, as well as UAV and aircraft. Development should examine active, passive and soft-kill responses that protect enough critical assets so that the Government and the ADF retain freedom of action. Defeating ballistic missiles and space platforms is assumed to be above Australia's desired range of capabilities;
- be capable of autonomous operations. An autonomous GBAeD system will ensure that the deployed land force will receive protection regardless of the operation's distance from bases, the physical environment, functionality of the ADF ADS or the capabilities of the coalition. To develop only part of the system—for example, the provision of response options—increases the risk of system failure and reduces GBAeD's contribution to achieving freedom of action;
- be capable of using information from coalition partners to produce an RBP that helps the supported commander;

- be able to move strategically by air and sea, and have mobility commensurate with supported formations, for example, by using armoured vehicles to support mechanised units, and person-portable systems for light infantry and special forces. The need for strategic mobility will limit the size and shape of GBAeD system elements; and

- be logistically sustainable for the operational viability period described in extant plans. This issue should also be considered as part of ADF force development more generally, for example, by encouraging some component commonality between land, naval and air platforms with similar roles.

PART 3
A CONCEPT FOR GBAeD 2030

This final part describes a concept for GBAeD 2030, and uses the combat functions to identify the essential characteristics of the system.[23] This part will also highlight a number of associated issues for the GBAeD system. The reason for providing this concept is to provide a lead to experimental design.

GBAeD 2030

This system provides the Australian Army with a BOS[24] that helps the commander to achieve freedom of action by protecting, or shielding, manoeuvre forces or assets from hostile aerospace activity. Creating an effective system requires an information subsystem that detects and identifies air vehicles using active and passive sensors. Sensors in this system will use

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23 See LWD 1, chap. 4.

24 See LWD 1, chap. 5.

different types of information to improve the accuracy of identification and provide redundancy. Information on space capabilities that influence operations may be obtained from open-source and allied estimates.

GBAeD 2030 also has a battle management subsystem that correlates information from sensors inside and outside the battlespace—including civilian and coalition systems—to produce a RBP. This subsystem also manages the logistic, liaison, training and planning aspects of the mission. GBAeD 2030 will include highly trained people who are able to manage ambiguous situations and to convert knowledge into useful advice that helps supported commanders to make better decisions.

GBAeD 2030 will require a response options subsystem that includes active decoys, passive response measures, and a mix of missiles, guns and directed-energy weapons. Response options should ‘plug’ into and ‘fight’ within any allied battle management architecture. More generally, GBAeD 2030 will need to be strategically mobile in ADF air and sealift assets, be scalable (that is, able to change its size or configuration quickly), provide value in terms of through-life costs, and be logistically sustainable. The main features and linkages of GBAeD 2030 are illustrated in Figure 3.

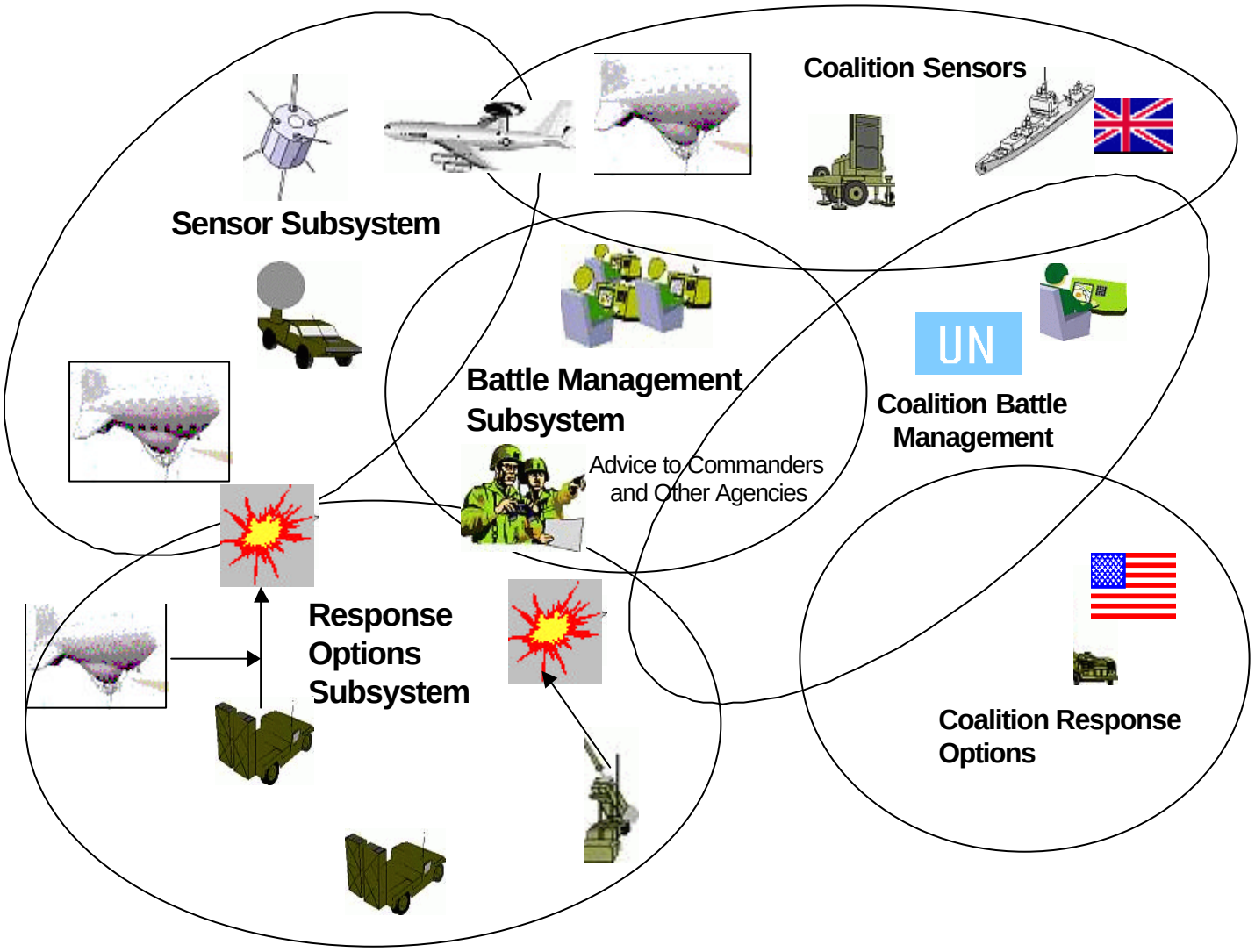

Figure 3: GBAeD 2030

GBAeD 2030—Achieving the combat functions

In this section the combat functions of *know, shape, shield, strike, sustain* and *adapt* are used to describe the essential characteristics of GBAeD 2030.

Know. GBAeD 2030 must firstly know the battlespace. This is the building block of the system, and the first force development priority for the AAN, because it will probably be the most complex task (in terms of system integration and probably operator training). Knowing the battlespace will require a system that provides a real-time picture of the battlespace's aerospace situation by correlating organic surveillance assets with the ADF ADS in order to create a relevant RBP. The real-time picture includes accurate identification of all aerospace vehicles (including satellite coverage) and their likely tasks (based on roles, tactical behaviour and emissions). Knowledge derived from the RBP will allow an accurate and timely threat assessment, and time to make decisions that enhance the commanders' freedom of action. The system will also draw on, and contribute to, the broader concept of the Sensor–Actor Architecture.[25] In order to know, GBAeD 2030 must be:

- **Networked.** The system must take full advantage of all the information produced by sensors within, and relevant sensors outside, the battlespace. Sensors must be able to pass data to the battle management agency without interruption or manual interface (air-gaps) in a multi-nodal network. Alternative channels for information between sensors and battle management agencies are required to avoid system failure by enemy action or

[25] See LWD 1, chap. 4.

electronic/computer faults. If the local battle management agency is destroyed or electronically isolated, other battle management agencies should be capable of providing the commander with the RBP and command functions.

- **Layered.** GBAeD 2030 must use all possible sources—including electromagnetic, audible, optical and maybe olfactory sources—to collect data. These data sources should provide multiple clues about the identity of an aerospace vehicle to provide the battle management agency with the best possible information to satisfy ROE. The system will need to cover the commander's entire battlespace.

- **Smart.** Smart sensors and battle management assist decision makers by detecting false information, assisting with threat prioritisation, analysing payloads and selecting response options. The intelligent system will advise on ROE and identification standards, and retain evidence about the commander's decision-making process.

Shape. Shaping involves an ability to either conceal or show the GBAeD force, with the intent of attracting the enemy's attack at our strongest point. This will require GBAeD 2030 to:

- **Lie.** The system must employ active deception measures such as emitters and decoys to give the enemy commander a false impression of the GBAeD system's coverage, strengths and vulnerabilities. To achieve this, the system's signature must also be indistinguishable from other energy sources in the friendly force.

- **Manipulate.** The system must allow selected threat aerial vehicles to locate and identify friendly force activity and dispositions in a way that misleads the enemy

commander. Manipulation of the enemy's battlespace picture will require an understanding of the roles and capabilities of each aerial vehicle.

- **Confuse.** GBAeD 2030 should be capable of introducing false information into the enemy's targeting cycle and to draw enemy reconnaissance or strike assets into traps. To do this, the GBAeD system should have its own decoys that replicate its signatures. The system must also confuse threat warning sensors, decoys and countermeasures.

- **Pre-empt.** The system must be capable of appearing at unexpected places in the battlespace. Pre-emption will require a high degree of strategic and tactical mobility.

Shield. GBAeD 2030 must be able to protect itself so that it is ready to fight when required. To achieve protection, the force must be:

- **'Survivable'.** Remaining 'operational' requires a system that can survive enemy action. The first element is the ability to lie and confuse (see section entitled 'Shape' above). The system should also use passive measures to hide from observation and attack. Should deception fail, the system must be able to withstand enemy attack. Each element of the system should employ active defensive measures to protect itself from attack[26] and include sufficient redundancies to cope with any degradation.

- **Resilient.** The system must withstand enemy and environmental degradation. While redundancy is built into the system through networking and layering, each component

[26] Such defensive measures might include organic infantry protection, particularly where crew sizes are small.

must be capable of maintaining a true picture in the face of cyber attack, physical attack and environmental stress.

Strike. The primary mission of GBAeD 2030 is to reduce the enemy's aerospace power through strike. Strike involves locating the target aerial vehicle; engaging the vehicle to neutralise, destroy or deter; and assessing the effect achieved to inform the RBP. Response options, which provide the ability to strike, should be able to 'plug' into and 'fight' along with a battle management system. Achieving this characteristic will require agreed standards for data transfer, and for the response subsystem to feed its results back into the RBP. In order to strike, the system must be able to:

- **Destroy.** GBAeD 2030 will employ lethal force to prevent all types of aerial vehicles (except space vehicles or ballistic missiles) from completing their mission. The types of lethal force may include kinetic energy, electro-magnetic energy, directed energy or any other suitable medium. Using an expensive missile to destroy large numbers of attacking weapons could be cost-prohibitive. For example, the system could be required to destroy a large 'swarm' of UAV or rockets cheaply and quickly. Weapons that do not rely on line-of-sight engagements may prove more effective in urban areas, the Pacific littoral and Australia's north.

- **Disable.** If possible, the system should have a response option that is capable of preventing an aerial vehicle from completing its mission without posing a lethal threat to any people on board.

- **Deter.** GBAeD's presence may deter an aerial vehicle from entering protected airspace. The system may be able to add to the deterrence effect by using its fire control

source to illuminate a vehicle in order to warn of the system's capability.

- **Assess.** The system must inform the battle management subsystem of the results of its actions, and advise on re-engagement in real time.

Adapt. As flexibility is one of the most desired qualities of supporting forces, GBAeD 2030 must be able to:

- **Move.** Individual elements must have sufficient strategic, tactical and battlefield mobility to support the manoeuvre force in the battlespace. Sea and air transportability is indispensable. The system should be capable of rapid deployment to areas outside Australia. An ability to keep up with supported formations is essential to achieving freedom of action.

- **Advise.** GBAeD commanders must advise unit commanders on passive measures to protect themselves from air attack and aerospace surveillance.

- **Evolve.** GBAeD systems should evolve as technology develops. Developing long-term relationships with industry will help to make this type of development possible.

Sustain. GBAeD 2030 must be sustained by a reliable, low-effort, dependable and cost-effective logistic system. In order to fulfil this requirement, the system must be:

- **Crewed.** Automation, robotics and artificial intelligence should be applied to reduce the number of people required to operate the system.[27]

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[27] In the best case, some response options might not require crews at all.

- **Supplied.** The system should have a minimal number of supply inputs. Improvements such as parts commonality and long-life power supplies will assist in fulfilling this requirement. Subsystems should automatically report the usage rates of consumables to the logistic management system. Ammunition packaging must prevent damage during handling, without increasing bulk. Ammunition should have a long shelf-life and not require any maintenance after manufacture. Using one type of surface-to-air missile, or a multipurpose kill mechanism, on ADF platforms may reduce logistic overheads.

- **Repairable.** System operators should be able to undertake initial diagnosis and component replacement repairs on their equipment. Built-in evaluation, failure prediction, and redundancy within the system will assist in fulfilling this requirement. Components should have a long, maintenance-free shelf-life. Built-in redundancy should allow continued engagements even after components have failed. Each weapon platform should be capable of identifying and engaging hostile targets in the event of system disruption.

Other factors

People. Jobs in GBAeD units will need to be reshaped for the AAN. By 2030, the Army should expect its recruits to possess advanced technical qualifications. These soldiers will probably have high expectations and the desire for challenging work. Personnel costs will continue to consume a large proportion of the budget. This cost may increase since recruits will probably be few in number.[28] GBAeD 2030 will therefore have to rely

[28] According to Schindlmayer, the ADF will find it difficult to maintain the current target size at 54 000 by 2020 due to broader

on a very small number of people, all of whom will demand highly satisfying work, and some of whom may not be physically capable of sustained hard work. Changing the approach to equipment specification, such as stipulating that all components must weigh less than 20 kg, might allow female and older soldiers to perform all detachment functions. Automated and robotic systems may be another means of addressing these issues, since they add to the challenge of work (by requiring operators with maintenance and programming skills) and may reduce the amount of heavy work and the number of people required.

Organisation. Changes to command-and-control systems, especially when aided by artificial intelligence and high-speed data transfers, should flatten the GBAeD command hierarchy considerably. This flatter hierarchy should allow GBAeD units to be smaller and possibly be commanded by lower-ranking officers. GBAeD might also become a 'purple' (ADF) force, given that it contributes to the effect of aerospace control.

Training. Future GBAeD officers and soldiers will need to provide comprehensive advice to commanders on the aerospace battle. This level of professional advice will require a thorough knowledge of friendly and threat systems, including ballistic missile defence and space-based sensors. Training should be conducted with the other services where such cooperation is effective and efficient.

'Human in the loop'. Future aerospace defence systems might not need human intervention by 2030. In these systems, sensors would detect and transmit a message to a central

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changes in Australian society. See T. Schindlmayer, *Defence Personnel Environment Scan 2020*, Commonwealth of Australia, Canberra, 2001, pp. 110–13.

computer. This computer would correlate and identify targets, and then transmit a fire command to an unattended launch pod that received mid-course guidance from another sensor. While an un-crewed system is technically possible within the timeframe, cultural and legal factors will make it essential for every system to include a person to make engagement decisions. Of course, advances in artificial intelligence and 'learning systems' might reduce the rate of human error, and even promote confidence in the idea of eventually removing humans.

Research and development. Research is essential to the creation of GBAeD 2030. This research should be conducted cooperatively with the RAAF, Royal Australian Navy (RAN), and our ABCA partners. Cooperation might involve direct investment in multinational weapons, battle management or sensor systems. Alternatively, it may involve taking the lead on a small part of the system while others conduct complementary studies. Either way, the Australian Army should be looking to start paying for its future GBAeD system now, rather than paying premium prices for finished products. Directed-energy weapons and battle command systems (particularly data fusion and identification) are critical research priorities.

Discontinuous change. The main problem with trying to determine a future GBAeD system is spotting the sources of change, particularly change that might be a complete break with the past. Such change may come from technological breakthroughs, changes in political relationships, or new cultural or belief systems. This concept should be regularly reviewed and updated as the GBAeD system develops in the AAN so that trends and events can be analysed as possible sources of discontinuous change.

CONCLUSION

This paper has outlined a concept for a future GBAeD system by relating the technological and warfighting context of 2030 to the system's contribution to the military roles described in FLW 2030. It is, admittedly, a single-service approach to what is fundamentally a joint endeavour. This concept is therefore a start to the discussion about the type of ADS that Australia should develop when the current elements and near-term acquisitions for the ADF ADS—including Jindalee, JP 117 Ground-based Air Defence, the AIR 6000 strike and fighter solution and Airborne Early Warning and Control—are due for upgrade or replacement.

This concept has stressed the important contribution that GBAeD, as part of a balanced force, makes to force protection. In assisting with force protection the GBAeD force not only destroys hostile aerospace threats, but provides information and advice so that deployed and enabling forces can either avoid or mitigate the impact of hostile aerospace attacks or reconnaissance. While GBAeD ultimately provides these functions as part of a larger aerospace defence system, it must also be able to fight autonomously in case the broader air-defence system is degraded by monsoons, enemy action or distance from Australian or allied bases.

This concept stresses the centrality of information to the system. Without information on the aerospace situation, the commander is blind and risks being disrupted by enemy aerospace power. The complexity of the aerospace environment makes a highly effective battle management subsystem essential; this subsystem must produce a RBP, assign targets to response options, and monitor the vital signs of the entire system. Developing an information system is therefore recommended as the priority for GBAeD development.

GBAeD 2030 will also be essential to the combined-arms team because it ‘shields’ the force and helps to achieve freedom of action. Shielding will be essential in any future operations because it will be impossible to discount any credible actor’s ability to create at least part of an aerospace effect, given the wide variety of aerospace platforms and the pervasive nature of space surveillance. Creating a system with sufficient mobility to keep up with the protected force is essential to achieving freedom of manoeuvre, which makes mobility the second force development priority.

GBAeD will also be an essential element of the ADF ADS and potentially a coalition-level integrated air-defence system. The GBAeD system of 2030 must therefore be developed with a ‘team’ focus in mind. The third force development priority is ensuring that GBAeD 2030 can accept information from other systems, and give information to response options that are temporarily assigned.

The response options must provide commanders with the right effect at the right place and time. As different types of aerospace weapons will threaten different assets, creating a mix of response options is essential to both effect and economy. Increasing the self-protection ability of the combined-arms team will contribute to force protection, as will creating a layered and mixed system of weapons. Soft-kill, passive measures and decoys could be considered to complement lethal response options.

The GBAeD system of 2030 will face many problems even before it is employed against an enemy aerospace threat. These problems will be technological, budgetary and cultural in nature, and solving them will require experimentation, research and cooperation with the other services and allies.

ANNEX A

JOINT CORE CAPABILITY IMPLICATIONS

Key Requirements

To succeed as part of an ADF joint task force, ground-based aerospace defence (GBAeD) will require:

- strategic and tactical mobility;
- direct links into the ADF ADS and manoeuvre force command and control (C2) system;
- a robust and foolproof information system;
- consideration when drafting rules of engagement (ROE); and
- a sound logistic system, based on a high degree of component complementarity with other ADF systems.

Developing GBAeD 2030 will require close cooperation with other ADF projects, such as Project Air 6000.

Implications

These requirements affect joint core capabilities in the following ways:

- **Command and Control.** GBAeD missions and tasking should be considered early in the ADF planning process to ensure that effective ROE are drafted. As the ADF ADS will exercise control over GBAeD 2030, the ADS must be capable of providing real-time data and voice (including imagery and sensitive intelligence) to GBAeD command posts. Responsibility for achieving this connection should remain with the Army; however, all joint or RAAF ADS

and C2 projects must also consider GBAeD 2030 requirements and capabilities. Control of GBAeD will probably be devolved to the RAAF, or even to a coalition partner; therefore GBAeD commanders, liaison officers and their supporting networks must be easily integrated into any C2 system. This level of integration will require procedural and equipment solutions. Identification Friend or Foe methods will also need to comply with coalition standards.

- **Intelligence, Surveillance, Target Acquisition and Reconnaissance.** Information from all ADF intelligence, surveillance, target acquisition and reconnaissance (ISTAR) assets, as well as other national assets such as civilian air traffic control and intelligence agencies, will provide input into the GBAeD recognised battlespace picture (RBP)and planning process. In the case of potential targets, these agencies must recognise that identification is just as important to GBAeD as detection. GBAeD commanders will also require detailed knowledge of mission areas for planning and rehearsals, including geospatial and physical data such as vegetation height and potential radar obstacles or sources of interference. Information on space reconnaissance assets—friendly, neutral or hostile—will be essential information for GBAeD commanders. Identification systems should correlate information from a wide variety of ‘clues’, include visual and oral signatures, flight path information and active transponders. Threat libraries will be essential to countermeasures, decoy detection and identification.

- **Manoeuvre.** Manoeuvre formations will need to incorporate real-time information on the aerospace situation into their information systems. If possible,

defensive aid suites on platforms should be capable of engaging hostile missiles or UAV in self-defence, based on warning and identification from the ADF ADS or GBAeD battle management system. GBAeD 2030 must be compatible with strategic mobility assets and must have similar tactical mobility to the defended asset. Cooperative engagement—linking air, naval and ground-based aerospace defence platforms—would provide a distinct warfighting advantage.

- **Offensive Support.** Information on offensive support missions should be available to the GBAeD battle management system in order to prevent the engagement of friendly aircraft, rockets or missiles in flight by GBAeD weapons.
- **Force Protection.** While GBAeD 2030 is a prime contributor to force protection, the system will also need protection in terms of threat warning, electronic protection, computer incident response, decoys and deception.
- **Logistics.** The logistic system should:
  - provide repair components and sub-assemblies, including moving those parts to and from facilities in Australia or overseas;
  - provide automatic replenishment of key consumables;
  - predict failures within subsystems, and advise on preventative maintenance; and
  - encourage high degrees of component compatibility. For example, research should be conducted to determine the risks and benefits of having a similar ‘anti-air’ missile on ADF air, maritime and land systems.

ANNEX B

IMPLICATIONS FOR BATTLESPACE OPERATING SYSTEMS

Key requirements

To succeed as a battlespace operating system (BOS) in a combined-arms team, GBAeD will require:

- tactical mobility and protection from aerospace threats;
- direct links with the ADF ADS and manoeuvre force C2 system;
- a robust and foolproof identification system;
- under some conditions, ground protection for certain key elements; and
- a sound logistic system, based on a high degree of component complementarity with other ADF systems.

Implications

- **Command and Control (C2).** GBAeD will help commanders to manage their airspace and advise on aerospace activity. Consequently, the ADF or coalition C2 system must provide GBAeD units with a detailed understanding of the commander's intent and subordinate plans. The system must also be able to accept information from GBAeD, particularly threat warnings, and information on the RBP for vehicles that can engage aerial targets.
- **Information Operations.** GBAeD will probably make a minimal contribution to information operations. Close coordination will, however, be needed if the information

operations plan requires some parts of the force to be visible to the enemy.

- **ISTAR.** GBAeD will provide a critical element of the ISTAR BOS; a robust link and common data-sharing standards between it and the major intelligence data-processing cell is therefore essential. Other sources in the ISTAR BOS will help to provide information on aerospace activity, geospatial information, and physical and electronic orders of battle.
- **Manoeuvre.** As the GBAeD system will probably have only a small number of people, the Manoeuvre BOS might be required to provide physical protection to GBAeD assets under certain conditions, particularly where enemy ground-forces provide a credible threat. Air manoeuvre forces will require Identification Friend or Foe, an ability to transmit mission information to GBAeD units, and perhaps a co-operative engagement capability for aircraft fitted with air-to-air missiles and sensors. Defensive aid suites on platforms should be capable of engaging hostile missiles or UAV in self-defence, based on warning and identification from the ADF ADS or GBAeD Battle Management Subsystem.
- **Offensive Fire.** The Offensive Fire BOS will be a critical user of airspace; an effective link with GBAeD units is therefore essential (especially if GBAeD is capable of engaging hostile artillery in flight).
- **Mobility/Countermobility.** The GBAeD system would require engineering support similar to the Offensive Fire BOS. Tasks might include digging, tree clearing, site preparation and camouflage.

- **Combat Service Support (CSS).** The CSS BOS would be required to:
  - deliver specialised parts, munitions and possibly laser or sensor chemicals to dispersed sites;
  - react to failure prediction; and
  - react to threat warnings and receive information from the RBP.

ANNEX C

GBAeD RISK IDENTIFICATION

Combat risk identification

The GBAeD system is an essential component of the commander's risk management plan, as it is intended to reduce the threat from enemy aerospace activity. The GBAeD system does, however, also have potential risks and vulnerabilities, including:

- vulnerability to neutralisation through electronic or cyber attack;
- inability to identify aerospace activity in time to neutralise its effects;
- inability to obtain sufficient accurate information on satellite activity and convert that information into useful intelligence;
- inability to protect assets from the broad range of threats that could be encountered, from large numbers of attacking missiles or aircraft, to a small number of sophisticated attacking vehicles like ballistic missiles or high altitude UAV, using a limited variety and small number of response options;
- the risk of being neutralised because of action against critical elements of the wider ADF ADS; and
- vulnerability to supply chain disruption.

Capability development risk identification

GBAeD 2030 requires a systematic approach to aerospace defence capability development. Some sources of risk include:

- failing to integrate GBAeD 2030 into other joint aerospace defence, knowledge, or logistics projects;
- failing to consider developments by likely coalition partners, or react to global aerospace developments;
- focusing experimentation on ‘high-end’ threats at the expense of ‘low-end’ threats;
- retaining the focus on weapons, leading to the possible inhibition of the development of the information subsystem; and
- failing to maintain sufficient stock of repair parts for the deployable force, which would increase the importance of protecting the supply chain.

ANNEX D

GBAeD CONCEPT BENEFITS

The main benefits of GBAeD 2030 are:

- As a capability, GBAeD is likely to increase in relevance in the AAN because more actors are likely to develop an ability to generate (at least) some aerospace effects.
- It provides national leaders with a low-resource and defensive military option to demonstrate resolve and deter or defeat hostile attacks. Under most conditions, the deployment of GBAeD could be explained as non-aggressive and non-escalatory.
- The system can operate effectively across a wide variety of terrain and physical conditions, either within Australia or at any distance from the Australian mainland. The system can remain effective for long periods, especially when personnel are rotated through established equipment.
- Subsystems can be used in war or warlike situations to provide information and response options as required.
- The system is intended to operate as part of a wider ADF ADS, but it can operate autonomously if required.
- The system helps to provide the commander with freedom of action by:
  - protecting essential ADF and Army assets from aerospace attack and surveillance (therefore enhancing force protection); and

  - providing timely and accurate information on hostile aerospace activity, allowing the commander to modify plans if necessary.

- GBAeD provides protection for ADF assets deployed as part of a coalition force, and can be integrated into a coalition aerospace defence system.

- A ‘plug and fight’ approach to development, based on adding more response options to the integrated sensor and battle management subsystems, should allow GBAeD protection to increase relatively quickly.

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