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# Improving strategic airlift with lighter-than-air platforms: A feasible concept for the Australian Defence Force?

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## Introduction

1. Lighter-than-air (LTA) transportation invariably evokes images of lumbering, unwieldy vessels travelling across the sky at glacial speeds. More unjustly, the impression of airships is always blinkered by the images of the various airship disasters of the 1930s. Among the most enduring of these images are those of the broken-backed *R101* airship<sup>1</sup> and the blazing *Hindenburg* zeppelin.<sup>2</sup> The adverse publicity following these airship disasters, along with the development of viable large heavier-than-air (HTA) aircraft, had effectively ended any serious consideration in using airships for mass transportation.

2. For more than half a century after the *Hindenburg's* demise in 1937, the airship was tagged as a suspect form of transportation.<sup>3</sup> However, in the past decade, there has been a resurgence of interest in the concept of airship transportation. The renewed interest in cargo airships is attributed to the harsh logistics lessons of recent major military conflicts; from Operation DESERT STORM in 1991,<sup>4</sup> through the Afghanistan conflict, to Operation IRAQI FREEDOM in 2003.<sup>5</sup> These conflicts underscored the need to rapidly transport huge volumes of defence material over long distances, especially in land-locked areas.

3. The need for rapid mobility is exemplified by the situation faced by the US 4th Infantry Division which was assigned to Northern Iraq during Operation IRAQI FREEDOM. When Turkey refused access rights to the United States, the need to re-position rapidly the entire Division and its equipment from the Mediterranean could not have presented a bigger logistical crisis. Additional C-17 aircraft, even if they were available, would not have changed the fate of the 4th Infantry Division. Airships could have made a difference.<sup>6</sup>

4. While LTA strategic airlift is being considered in a number of countries, including the United States, there is a possibility that this concept may be feasible in the Australian context. Current Australian strategic stance has led to a more expeditionary focused Australian Defence Force (ADF), and significant force elements have been deployed for overseas operations in recent times. Australia's commitments and capabilities may be much smaller than those of the United States, but its concerns in strategic airlift are no less than those of its major ally. In relative terms, the ADF too had experienced difficulties with its airlift capability in recent operations.<sup>7</sup> In the light of this apparent shortcoming, this paper will examine the viability of using LTA platforms to improve the ADF strategic airlift capability.

5. **Scope.** This paper will first identify the strategic lift capability gap in the ADF. It will then discuss the options available in meeting this capability gap, before examining the emergent LTA concept in providing strategic airlift. Finally, the paper will examine the feasibility in adopting an LTA capability for meeting the strategic airlift requirement in the ADF. This paper presents a conceptual proposal, and all information used in its writing is confined to open-source material.

## **Aim**

6. The aim of this paper is to propose the use of LTA platforms to improve the strategic airlift capability of the ADF.

## **ADF STRATEGIC LIFT—THE CAPABILITY GAP**

### **Strategic lift requirement of the ADF**

7. The ADF is becoming an increasingly expeditionary focused force: firstly, current Defence policy implies that there is an increased likelihood for the ADF to deploy overseas;<sup>8</sup> and secondly, the ADF envisions itself being engaged in the future concept of ‘globalised’ warfighting.<sup>9</sup> Concomitant to this expeditionary focus is the requirement for a strategic lift capability to support the rapid mobility of ADF combat elements. The strategic lift capability required is dependent on the ‘scale, time and space’ of an ADF deployment.

8. **Scale.** The scale of the ADF’s commitment for any future overseas deployment is dependent on the strategic posture of the government of the day. While the current official prediction in planning for the ADF strategic lift requirement is for the deployment of a battalion-sized force,<sup>10</sup> recent experience has shown that the size of an ADF deployment could be much bigger; the ADF deployment for INTERFET in East Timor was a brigade-plus sized force.<sup>11</sup>

9. **Time and space.** Considering the ADF’s vision of being engaged in ‘globalised’ warfighting, the ADF strategic lift capability must be able to transport rapidly a fighting force over strategic distances to the final destination in theatre.<sup>12</sup> ‘Globalised’ warfighting also means that it would be prudent to assume further distances, rather than nearer, in planning for the ADF’s lift requirement. In addition, the ADF must be able to operate in adverse battlefield conditions, which may include shortcomings such as rugged and landlocked areas of operation, and inadequate air basing and port facilities. Finally, the geography and size of the Australian continent must be taken into consideration when planning for any military capability, not the least transportation. Even setting aside the need to deploy beyond the shores of Australia, internal transportation within continental and littoral Australia still may involve significant distances.

10. **Meeting the ‘scale, time and space’ requirement.** The conventional strategic lift model utilises significant numbers of varying cargo carrying assets including cargo ships and aircraft, both military and commercial, to meet the ‘scale, time and space’ requirements of rapid mobility. Additionally, strategic lift often is complemented with intra-theatre lift capabilities, such as helicopters and tactical air transports, to insert the fighting force to remote regions.<sup>13</sup> For the ADF, the ideal strategic lift model would be one that is able to provide a ‘Fort-to-Fight’ movement capability.

### **ADF strategic lift capability—short-medium term**

11. Strategic lift in the ADF is provided by the Royal Australian Air Force’s (RAAF) airlift assets, the Royal Australian Navy’s (RAN) sealift platforms and sources external from the ADF. As current Defence policy implies that there is an increased likelihood of ADF elements being deployed, the Defence Capability Plan (DCP) was ‘re-balanced’ to include proposals to enhance the ADF strategic lift capability.<sup>14</sup>

- a. Airlift. The current strategic airlift assets of the RAAF are 24 C-130H/J-30 aircraft and four Boeing B707 transport/tanker aircraft.<sup>15</sup> Under the DCP, the older C-130H aircraft will be refurbished to extend the platform Life of Type until at least 2020.<sup>16</sup>

Additionally, acquisition of five Airbus A330-200 Multi Role Tanker Transports (MRTT) has been approved to replace the B707 aircraft.<sup>17</sup>

- b. Sealift. The RAN strategic lift assets consist of two Landing Platforms Amphibious (LPA) and one Heavy Landing Ship (LSH).<sup>18</sup> The DCP proposes for the two LPAs and the LSH to be replaced with two larger amphibious ships and a strategic sealift ship.<sup>19</sup>
- c. Allies and commercial support. The ADF relies heavily on external sources to provide the strategic lift requirement for any major deployment of its forces. Support from allied forces and commercial capabilities was significant during all recent major ADF operations beyond the shores of Australia.<sup>20</sup>

12. **Beyond the DCP.** All of the DCP strategic lift proposals, if followed through successfully, will be realised fully only by the end of the next decade. Nevertheless, with the acquisition of substantially more capable sealift platforms, the overall ADF strategic lift capability will be significantly enhanced as a whole.

### Requirement/capability gap

13. **What the ADF can provide.** The C-130 fleet will be able to provide a reasonably good medium/tactical airlift capability until at least 2020. Also, before the end of the next decade, the DCP will have attained a significant strategic sealift capability for the ADF.<sup>21</sup> However, it must be noted that sealift is only one part of strategic lift, and dependency on slow sea transportation prohibits efficient and timely deployment of fighting forces to locations where they are needed. Sealift alone does not have the speed and reach that is required to achieve a rapid mobility capability.

14. **What the ADF cannot provide.** Speed and reach obviously are achieved most effectively by strategic airlift platforms. Unfortunately, the ADF does not possess an adequate strategic airlift capability. Recent operations in East Timor, Afghanistan and Iraq have shown that there is a real need for additional airlift capacity in the ADF, as a considerable amount of work had to be contracted out to commercial heavy-lift aircraft operators.<sup>22</sup>

- a. **C-130 medium-lift aircraft.** While the C-130 aircraft is one of the most versatile and capable aircraft in its class, it is not a true strategic airlift platform, even though it is notionally labelled as such in the Australian context. With modest cabin volume and a payload of barely 16 tonnes, it will be hard pressed for a fleet of 24 C-130 aircraft to perform strategic lift missions that potentially could be in the scale of thousands, if not, tens of thousand of tonnes.<sup>23</sup>
- b. **A330-200MRTT.** Contrary to what its name may suggest, the A330-200MRTT cannot be expected to contribute greatly to strategic airlift tasks. The wide-body A330 does offer a significant airlift capability,<sup>24</sup> but the quantity of five platforms is already significantly short of the number that is required by the RAAF to support its fighter force.<sup>25</sup> As a result, it is unlikely that the A330 can be diverted from its main air-refuelling role to perform any significant strategic airlift tasks. At most, the A330 will deploy together with the RAAF's combat aircraft, providing the strategic airlift needs of the accompanying elements.

15. **The capability gap.** Rapid mobility is essential for performing the future missions envisioned in the ADF's involvement in 'globalised' warfighting. To achieve rapid mobility, a conventional strategic lift model usually employs a combination of capabilities, which include high-speed strategic

airlift aircraft, large-capacity sealift platforms and intra-theatre medium/tactical lift assets. The ADF will be able to provide two elements of this combination of capabilities: intra-theatre airlift through the C-130 aircraft, and strategic sealift through very capable sealift platforms. Unfortunately, the ADF lacks the element of strategic airlift capability that is necessary in achieving rapid mobility. With only the C-130 aircraft and A330-220MRTT in its inventory, the ADF's most glaring shortcoming in rapid mobility is the acute lack of strategic airlift assets.

16. On a broader perspective of the ADF capability as a whole, the projected capability mix of the ADF is likely to be unbalanced if strategic airlift is not improved. The ADF needs to balance its strategic airlift capability against the highly capable capabilities that are being introduced into the ADF. Capabilities such as the Joint Strike Fighters, Armed Reconnaissance Helicopters, advanced C4ISREW<sup>26</sup> platforms and main battle tanks are less likely to achieve their full potential without the support of a proportionately capable strategic airlift capability. The lack of strategic airlift platforms, being the weak link in the ADF strategic lift capability, potentially could be also the weak link of the ADF capability as a whole.

### **OPTIONS FOR STRATEGIC AIRLIFT IN THE ADF**

17. The ADF needs a 'Fort-to-Fight' lift capability to deliver combat forces into an objective area over strategic distances. Lacking the strategic airlift assets to achieve this capability, the ADF may opt to use conventional HTA strategic airlift platforms to fill the capability gap, or alternatively, explore a viable non-conventional solution.

#### **Conventional HTA strategic airlift options**

18. **Conventional platforms.** There are limited choices for strategic military airlift platforms in the current aerospace industry. The most viable platform that meets the ADF requirement is either the heavy-lift C-17 Globemaster III (maximum payload 76 tonnes), or the smaller Airbus A400M (maximum payload 37 tonnes). Another possible, but less likely, candidate is the Antonov An-70 (maximum payload 47 tonnes).<sup>27</sup> While the C-17 has twice the A400M's maximum payload and 50 per cent more volumetric capacity, its purchase price of US\$150 million is twice that of the A400M and life-cycle costs could be three times greater.<sup>28</sup> On the other hand, the A400M may have characteristics that could be well suited to the ADF and its airlift needs; its cabin volume and payload are more than twice that of the RAAF's C-130s. Airbus is promoting the A400M as a higher capacity replacement or supplement for the C-130 in both the tactical and strategic modes.<sup>29</sup> Notwithstanding the platform type, any decision for outright acquisition of sufficient conventional strategic airlift aircraft to meet the entire ADF requirement is likely to involve prohibitive costs.

19. **Lease/acquisition.** Considering the cost pressures of acquiring conventional strategic airlift aircraft, the temptation for Australia is to meet its short-medium term additional military airlift needs by leasing a small number of strategic airlift aircraft, such as the C-17, A400M or even the An-70. Ideally, the lease arrangement would include options for future outright acquisition of the platforms. This cost and risk reduction strategy has been adopted by a number of countries with strategic airlift concerns similar to Australia.<sup>30</sup>

20. **Ad hoc commercial support.** There are obvious drawbacks in utilising commercial air transport to meet the ADF strategic airlift needs. Firstly, Australia's air transport industry operates in a highly efficient business environment with little or no surplus capacity. As a result, the ADF will be forced to source heavy-airlift capabilities from foreign commercial operators. Secondly, there

are limited commercial operators even in the international air transport industry that can provide the capabilities required by the ADF, particularly for dangerous and out-sized military cargo. This drawback is compounded by limited timeframes that often characterise force deployments; the ADF may need to secure commercial airlift capacity in a timeframe of days, rather than weeks or months, which would be normal commercial practice. Finally, even when there is access to these commercial capabilities, the fact remains that the scope for commercial operators to operate in an unsecured environment is very limited.<sup>31</sup> In short, the continued dependency on commercial support for the ADF strategic airlift needs would entail an unacceptably high degree of strategic risk.

21. **Allied support.** Historically, the ADF's overseas operations have drawn heavily on allied forces' resources. However, major allies that have traditionally provided strategic airlift support to the ADF are facing significant challenges themselves in meeting their own heavy-airlift needs.<sup>32</sup> While some degree of assistance could be expected under the auspices of formal alliances or ad hoc coalition arrangements, Australia cannot expect allies to provide unqualified levels of support. Considering that almost all of its allies are facing strategic airlift difficulties, Australia must be able to provide the larger part of its own airlift needs.

22. **Limitations of HTA strategic airlift.** There are significant shortcomings in choosing any of the above options, or mix of options, to meet the ADF strategic airlift needs. The most obvious shortcoming is that conventional HTA airlift platforms are costly to acquire or lease, operate and maintain. As defence budgets become more constrained, the escalating costs of HTA platforms are making them increasingly less affordable. Yet, ironically, cost is not the biggest shortcoming; there are inherent deficiencies in the conventional strategic lift concept itself. The conventional strategic lift construct of sea/air platforms complemented by intra-theatre lift vehicles has been demonstrated in recent major military operations to have serious deficiencies. In addition to having large logistic footprints, this conventional model could not overcome challenges such as logistical bottlenecks at reception facilities, lack of air basing and port facilities, and difficulties in direct delivery into rugged land locked areas. The best that could be achieved by the traditional strategic lift model is phased or incremental force arrival; traditional strategic lift could not provide a rapid mobility capability where 'ready-to-fight' forces are delivered to the destination in 72 hours, not 72 days.<sup>33</sup> There is certainly a need to explore an alternative to HTA strategic airlift.

### **Non-conventional airlift options**

23. As HTA transportation is unable to project decisive combat forces to the battlefield effectively, there is a need for military forces, including the ADF, to seek alternative means for flexible, high speed and affordable airlift vehicles. As new technologies are being developed, the ADF must consider the imaginative ways that technology could be exploited for military purposes.<sup>34</sup> Consequently, the ADF needs to explore innovative, but viable, concepts for alleviating its strategic airlift concerns.

24. **LTA strategic airlift—the most promising prospect.** There have been numerous conceptual airlift systems mooted to fill the demands of future warfighting concepts. While the viability of most of these concepts is dependent on risky predictions of future advances in technology, a number of the concepts are already technologically viable. Among these viable concepts are the Wing-in-Ground Effect Vehicle, Unmanned Aerial Vehicle and large cargo airship. These particular concepts are not risky 'futuristic' propositions; they either have been proven, or the technologies are in place to develop them into viable systems. Among these viable non-conventional strategic airlift options, studies have identified that the most promising option is LTA strategic airlift.<sup>35</sup>

## THE EMERGING CONCEPT OF LTA STRATEGIC AIRLIFT

### Technology catching up with concept

25. LTA heavy-lift has been explored for decades, but it is only now that all the necessary technological building blocks are finally in place to build large LTA vehicles. The possibility of creating a magic-carpet-like capability can be attributed to advances in technologies of material, control systems, propulsion, avionics and computer design tools.<sup>36</sup>

26. The adaptation of the hover-skirt for use in LTA vehicles, fly-by-light controls and thrust-vectoring technologies are transforming the airship from a lumbering, unwieldy vessel into a highly manoeuvrable vehicle.<sup>37</sup> Material revolution, which includes Eoprene, Tedlar and Kevlar, is enabling the development of lighter, stronger and bigger airship envelopes and structures.<sup>38</sup> Other critical LTA technological innovations include advanced lightweight water-recovery propulsion systems, bow-thrusters, lightweight power plants and automated water ballast systems. Technology finally is making the large airship a viable concept.<sup>39</sup>

27. **Large cargo airships.** Large cargo airship development has attracted considerable interest from a number of companies in the aerospace industry, including major companies such as Lockheed Martin and Boeing.<sup>40</sup> However, CargoLifter from Germany and Advanced Technologies Group (ATG) from the United Kingdom are two companies that have done the most substantial developmental work on large cargo airships.<sup>41</sup>

- a. **CL160.** CargoLifter was developing the CL160 semi-rigid airship, which has a lifting capacity of 160 tonnes. The CL160 was scheduled for its first flight in 2005. Although CargoLifter unfortunately became insolvent in 2002, the concept of large airships was greatly advanced by the company. The CL160 was already in the advanced phase of development; the proof-of-concept 'Joey' prototype had been flight-tested and a SkyShip 600B was already acquired for crew training.<sup>42</sup>
- b. **SkyCat.** ATG's prospects are much brighter with its current development of the SkyCat class of hybrid non-rigid airship. The three models, SkyCats 20, 200 and 1000, have respective payloads of 20 tonnes, 200 tonnes and 1000 tonnes.<sup>43</sup> The first SkyCat 20 is due to be completed and delivered to its customer, and the construction of SkyCat 200 is already under way.<sup>44</sup> However, the biggest boost for ATG came from the recent announcement by the British Ministry of Defence (MoD) confirming that the SkyCat 1000 is being seriously considered for the Royal Air Force. MoD officials believe that the first platform could be ready for use as early as 2010.<sup>45</sup>

### Overcoming LTA shortcomings

28. Although there is undoubtedly a degree of unfounded prejudice surrounding airships, there were real shortcomings in operating large LTA vehicles. Other than its apparent vulnerability, the most notorious shortcomings of a large LTA vehicle are its susceptibility to adverse weather and poor close-to-ground manoeuvrability.

29. **Vulnerability.** The behemoth size of an LTA platform at once conjures up images of it being an easy target to be shot down. Yet, this may not be necessarily true. Clashes between airships and U-boats in World War II have shown that airships were not easy military targets to destroy.<sup>46</sup> Many military HTA platforms are as vulnerable as LTA vehicles; a C-17 aircraft caught without cover

would hardly survive in a missile attack. In fact, the airship's very low infra-red and radar signatures actually make it less vulnerable to missile threats.<sup>47</sup> Additionally, the airship has a very high degree of intrinsic graceful degradation due to its envelope's low-pressurisation. Most of the passengers and crew of the *Hindenburg* escaped and survived the crash, which is unlikely if an airliner lost a wing.<sup>48</sup> In short, vulnerability should not necessarily be a problem if the airship is employed in a stand-off role or where air superiority is maintained, which is not unlike the normal employment of HTA strategic airlift platforms.

30. **Susceptibility to adverse weather.** The airship is more susceptible to adverse weather due to its large size-to-weight ratio and slow speed. However, while LTA vehicles are relatively more weather sensitive, studies have shown that airships can operate effectively in most weather conditions. According to British MoD estimates, a launch and recovery capability in up to 30-knot winds should enable an airship to achieve an 80 per cent availability rate. The MoD estimates also suggested that a 70-knot airship would be able to transit upwind in about twice the time taken by a medium-sized helicopter. A separate British study concluded that military airships could achieve a weather-related availability rate of 77 per cent in most European weather conditions, which are not the most benign in the world.<sup>49</sup> With advanced meteorological forecasting systems, and appropriate operational decision-making and tactical employment, LTA vehicles should be able to achieve a high degree of operational efficiency.

31. **Poor close-to-ground manoeuvrability.** Manoeuvrability close to the ground is perhaps the most intractable problem that airships have always faced. However, this Achilles' heel of airship operation is being overcome by advanced technologies such as the hover-skirt, fly-by-light controls and vectored-thrusts beyond 90°. The improvement in manoeuvrability of airships equipped with these technologies was reported to be outstanding.<sup>50</sup> Proof-of-concept flight-tests in France have demonstrated that airships fitted with advanced control systems were able to manoeuvre and fit into highly regulated air traffic environments.<sup>51</sup> Apart from providing better manoeuvrability, advances in airship control systems also enable a drastic reduction in the large number of ground crew that were previously required to manage launch and recovery operations.<sup>52</sup>

### **Current LTA strategic airlift concept development**

32. **Power projection through LTA strategic airlift.** Apart from not needing airfields for their operation, the characteristics of airships that entice military strategists are their extremely long endurance and large payload potential. Proponents of LTA strategic airlift in the US Pentagon suggested that military forces equipped with airships could move tonnes of equipment significantly faster than the typical speeds attained today.<sup>53</sup> For example, the US Navy estimated that an airship could be deployed from the East Coast of the United States to the Persian Gulf in 103 hours, compared to 442 hours for surface vessels (assuming Suez passage).<sup>54</sup> Therefore, it is not difficult to imagine the power projection potential of LTA strategic airlift. Using a fleet of airships with heavy/ultra-heavy lift capacity, a fully capable military response can be projected inter-continentially within days, rather than weeks.<sup>55</sup>

33. **HULA.** The US Joint Chief of Staff (J-4 Mobility Division) is investigating a number of projects related to hybrid airships.<sup>56</sup> While the US Army is an obvious supporter of LTA strategic airlift, another strong proponent of the concept is the US Navy, which had learned the harsh logistic lessons of Operation IRAQI FREEDOM. The Naval Air Systems Command (NAVAIR) has undertaken preliminary work on a conceptual family of hybrid airships called Hybrid Ultra-

Large Aircraft (HULA). HULAs would be LTA vehicles with a payload of several hundred tonnes and are envisioned for several military missions. The HULA for strategic lift may carry up to 500 tonnes of troops and armour for more than 5000 miles at 60–90 knots, cruising just off the surface to 10,000 feet.<sup>57</sup>

34. **Walrus ATD.** NAVAIR is currently discussing the HULA concept with the Pentagon's Defence Advanced Research Projects Agency (DARPA). Recently, DARPA released a draft solicitation for an Advance Technology Demonstration (ATD) program to prove the concept of large lifting air vehicles.<sup>58</sup> The US\$10 million ATD program, named Walrus, plans to flight-test a scaled prototype with comparable C-130 airlift capability in 2008. The full-scaled prototype would be capable of carrying 500 to 1000 tonnes over 6000 nautical miles. DARPA's concept involves the deployment of a combined-arms unit, battle-ready to fight for 3 days, direct to the theatre of operations within 96 hours. This would circumvent the need for slow sealift, or to break up the unit to deploy it by fixed-wing aircraft and helicopters.<sup>59</sup>

### **Commercial and civil applications**

35. The development of a new military capability is likely to be more viable if it can leverage off the potential market for commercial and civil applications of the capability. The prospects for commercial and civil applications of LTA transportation are very encouraging; market studies suggest that up to 200 heavy-lifting airships could be required worldwide.<sup>60</sup>

36. **Commercial applications.** Cargo airships could revolutionise the global transport industry. Fresh produce could be transported over vast distances, and manufactured goods or other commodities conveyed back on return legs. LTA transport would be significantly less costly than HTA transport and slightly more expensive than slow sea transport.<sup>61</sup> The transportation of cargo directly from source to distributors would eliminate much of the intermediate handling that is necessary in transporting products to and from airports, seaports and railheads. Potential users of cargo airships also include construction, mining and oil companies, which need to transport large payloads. Currently, feasibility studies being done are conducted in the United States on using airships to move large payloads over difficult terrain, such as in the Arctic or Siberia.<sup>62</sup>

37. **Civil applications.** LTA mass transportation has enormous potential in countries with under-developed transport infrastructure. Cargo airships not only could provide airlift for industrial items, but also could respond to natural disasters in a timely and adequate fashion. Airships could access areas struck by disasters such as earthquakes and floods much better than current modes of mass transportation. Humanitarian missions could be dispatched rapidly to deliver food and medical care to remote areas of the world that lack modern transportation infrastructure. Additionally, the airship's ability to embark and disembark anywhere could provide a solution to the difficult task of transporting hazardous material or waste, as they must be transported via circuitous routes to avoid populated areas.

### **FEASIBILITY IN ADOPTING LTA STRATEGIC LIFT IN THE ADF**

38. While LTA strategic airlift could be proven a viable concept, it must be feasible in the ADF context. LTA strategic airlift not only must be able to fit into the ADF capability requirement, but also be well suited to the ADF warfighting concepts. Additionally, cost implications must also be considered in introducing LTA platforms to improve the ADF strategic airlift capability.

### Fitting into the ADF capability requirement

39. **Filling the capability gap.** The strategic lift capability gap in the ADF has been identified as the lack of strategic airlift assets; the gap between the ADF's large-capacity, but slow, strategic sealift capability and its capable, but low-capacity, intra-theatre airlift capability. A conventional solution to this capability gap would be to acquire conventional heavy-lift aircraft. However, HTA solutions are not only costly, but also do not provide answers to the inherent problems of the traditional strategic lift concept. Considering the limited options that are available, LTA strategic airlift is certainly a viable solution to fill the ADF strategic lift capability gap.

40. **Fitting into the ADF.** The expectation of airships to be an all-encompassing capability to fulfil all the ADF strategic lift needs would be unrealistic. The ADF overall strategic lift model still will involve various cargo ships and aircraft to meet the 'scale, time and space' requirements of rapid mobility. However, the integration of LTA platforms with other elements of the ADF strategic lift capability will realise a significantly more capable overall system. More importantly, the introduction of LTA strategic airlift will not generate unnecessary capability redundancies; requiring neither the replacement nor paying-off of whole capabilities, which would not be fiscally or operationally viable. Rather than being an isolated capability, LTA strategic airlift platforms would fit effectively into the ADF 'system-of-systems' strategic lift capability.

### ADF warfighting concept

41. The ADF strategic airlift capability needs to meet not only current ADF airlift requirement, but also the rapid mobility requirement of the future 'globalised' warfighting concept envisioned by the ADF. Additionally, the future warfighting concept also requires a high degree of flexibility in the strategic airlift capability. The rapid mobility capability and flexibility of LTA strategic airlift may be illustrated by a broad description of the probable concept of operations.

- a. **Broad concept of operations.** LTA platforms could easily satisfy the ADF's rapid mobility requirement to embark a combined arms team at its base, transport it over strategic distances, while maintaining unit cohesion, and roll it down the ramp near the objective area ready for combat. The period from embarking to engaging the enemy anywhere in the world could be in a timeframe of days, rather than weeks. This rapid mobility capability could be achieved in spite of the enemy's anti-access measures that close airports and seaports. Additionally, LTA platforms could meet the complimentary airlift needs for intra-theatre re-deployment and force resupply in support of inserted forces.
- b. **Flexibility.** In the ADF context, LTA platforms normally would be utilised as part of the larger strategic lift system for the deployment of large forces. The significant improvement of the overall strategic lift system with the integration of LTA platforms would enable efficient and timely deployment of ADF forces. However, LTA strategic airlift also could be employed as a stand-alone strategic lift capability to project rapidly small, but highly capable, 'ready-to-fight' forces in time-critical operations.
- c. **Rapid projection of 'ready-to-fight' forces.** An airship with a 500-tonne payload will be able to move a platoon of four armoured fighting vehicles, their personnel and initial combat stores in a single lift.<sup>63</sup> This means that a flight of three airships could possibly provide a rapid mobility response of a 'ready-to-fight' force of a full company of mechanised troops. The same three-ship capability also could deliver similar

‘ready-to-fight’ results when deployed with a squadron of combat aircraft and their accompanying air-refuellers, as substantially larger amount of weapons and stores can be transported more rapidly than current mode of transportation allows.

42. **Secondary role.** LTA platforms are currently being actively developed for C4ISREW functions.<sup>64</sup> Although there are dedicated development of C4ISREW airships, there are no potential conceptual or technological barriers for LTA strategic airlift platforms to perform C4ISREW functions as a secondary role. This additional role of airships would be an attractive option for the ADF; C4ISREW not only is a critical element in concepts like Network Centric Warfare and Effects Based Operations that the ADF espouses,<sup>65</sup> but also essential if the ADF intends to develop a missile defence capability.<sup>66</sup>

### **Cost implications**

43. **Acquisition, operating and whole life-cycle costs.** Studies by the British MoD showed that airships were a third cheaper to operate than fixed-wing aircraft. Estimates on whole life-cycle costs also revealed similar savings.<sup>67</sup> While there is no current information on the actual initial procurement costs of large LTA cargo platforms, an approximate cost could be derived from using the ‘square-cube’ law.<sup>68</sup> The law basically suggests that the cost effectiveness of helium-filled airships improves at a payload-to-cost ratio of 2:1. The unit price of the SkyCat 20, which has a payload of 20 tonnes, is from US\$23 million to US\$28 million.<sup>69</sup> Therefore, the initial procurement cost of a 200-tonne payload LTA platform could be approximated at US\$115 million to US\$140 million, which is slightly lower than the cost for a C-17 aircraft.

44. **Cost effectiveness.** While the notional 200-tonne payload LTA platform and the C-17 aircraft have similar acquisition costs, the notional airship would have more than two and a half times greater payload. Additionally, the operating and whole life-cycle costs of LTA platforms could be three times lower than HTA platforms. While these cost figures are highly speculative, they at least demonstrate that LTA strategic airlift is not likely to be grossly beyond financial viability. Considering the potential capabilities that LTA platforms can offer the ADF, LTA strategic lift is a feasible concept in terms of cost effectiveness as compared to HTA strategic airlift options.

45. **Affordability.** An argument against adopting LTA strategic airlift in the ADF could be whether it would be a financially affordable proposition; defence budgetary constraints may prohibit consideration of acquiring LTA platforms to improve the ADF strategic lift capability. Then again, the costs of conventional HTA options also would be equally, if not more, prohibitive under the same budgetary constraints. The question of the financial feasibility of any strategic airlift options will be moot if budgetary constraints do not allow resources to be allocated to improve the ADF strategic airlift capability.

46. On the other hand, it has been identified that the ADF has a critical strategic airlift capability gap; the gap must be filled to avoid the risk of the ADF losing the ability to perform both present and future warfighting roles. If the ADF is resolute in maintaining its ability to perform these warfighting roles, there will be no alternative but to allocate resources to satisfy the critical requirement of strategic airlift. In this case, the concept of using LTA platforms to improve the ADF strategic airlift capability is certainly a feasible proposition that deserves serious consideration.

## Conclusion

47. The ADF is an increasingly expeditionary focused force that requires a rapid mobility capability to perform its present and future warfighting roles. Ideally, the rapid mobility capability would be able to provide a 'Fort-to-Fight' movement capability. In view of this rapid mobility requirement, current defence capability planning includes a series of proposals that will enhance the ADF strategic lift capability. Even so, there is an obvious capability gap that is not addressed; the ADF lacks the element of strategic airlift capability which is essential in providing a seamless rapid mobility capability.

48. The conventional solution to improve the ADF strategic airlift capability would be to employ HTA strategic airlift aircraft. However, the acquisition of sufficient HTA platforms to meet the entire ADF strategic airlift requirement is likely to be prohibitively expensive. Furthermore, continued reliance on support from allied forces or commercial sources is also not a viable option, as dependency on external sources for the ADF capability needs would be strategically risky. However, there is an even greater shortcoming of conventional HTA solutions. The conventional strategic lift model that utilises HTA platforms is inherently deficient; it could not provide a 'Fort-to-Fight' movement capability that delivers 'ready-to-fight' forces rapidly to the final destinations in theatre. Considering the drawbacks of HTA solutions, viable non-conventional options need to be explored to improve the ADF strategic airlift capability, and the most viable of these options is LTA strategic airlift.

49. While LTA mass transportation is not a new concept, it is only now that it is possible to build viable large airships due to a series of advances in LTA related technology. Additionally, technological innovations are also overcoming the shortcomings of LTA platforms, which previously had prevented efficient operation of airships. The increasing viability of large cargo airships has drawn the interest of military strategists, who are attracted to the tremendous power projection potential of LTA strategic airlift vehicles. The viability of developing military LTA airlift platforms is also greatly supported by the promising prospects that cargo airships have for commercial and civil applications.

50. LTA strategic airlift is a feasible concept in the Australian context. Firstly, LTA platforms not only would be able to fill the ADF strategic lift capability gap, but also fit effectively into the overall ADF strategic lift 'system-of-systems'. Secondly, LTA platforms would be able to fit into the ADF future warfighting concept: either as an element in the larger strategic lift system to deploy large forces effectively; or as a stand-alone capability that can be used to project rapidly smaller 'ready-to-fight' combat elements. Additionally, there is an attractive secondary role that LTA strategic airlift platforms can perform in C4ISREW functions, which is increasingly critical for the ADF capability. Finally, LTA strategic airlift is a cost-effective option in improving the ADF strategic airlift capability, as compared to adopting wholly a conventional HTA option.

51. The development of LTA mass transportation has come a long way; modern large airships are not the lumbering, unwieldy vessels of the past, but rather they are becoming a truly viable concept. Considering the advantages of LTA platforms that could be exploited by the ADF, LTA strategic airlift certainly is a feasible proposition that should be seriously considered to improve the strategic airlift capability of the ADF.

## Endnotes

1. B. Heydt, 2003, '5th October 1930: The R101 Airship Disaster', *British Heritage*, Dec 2003/Jan 2004, Vol. 24, No. 7, Cowles Enthusiast Media, Harrisburg, UK, p. 16.
2. A. Jeziorski, 1995, 'Rigid Returns', *Flight International*, 29 Nov–5 Dec, Vol. 148, No. 4500, Reed Business Information, Surrey, UK, p. 34.
3. Nevertheless, airships managed to maintain a niche market for lower level commercial applications such as advertising, tourism and television broadcasting; the famous Goodyear 'Blimp' has been a familiar sight at major sporting events for several decades. See K. Hayward, 1998, *The Military Utility of Airships*, RUSI Whitehall Papers 42, Royal United Services Institute for Defence Studies, London, p. 9.
4. N. Cook, 1995, 'Giant Airships: Shifting the Load of the Future', *Jane's Defence Weekly*, Oct 28, Vol. 24, No. 17, Jane's Information Group Ltd, London, p. 4.
5. J.A. Tirpak, 2003, 'The Squeeze on Air Mobility', *Air Force Magazine*, Jul 2003, Air Force Association, Arlington, US, pp. 23–9.
6. R. Barnard, 2003, 'Iraqi Conflict Brings Interest in Military Airships', *Sea Power*, Jul, Vol. 46, No. 7, Navy League of the United States, Washington, p. 1.
7. For details of reported difficulties in recent ADF operations: INTERFET/UNTAET, see Commonwealth of Australia, 2002, *Management of Australian Defence Force Deployments to East Timor*, The Auditor-General Audit Report No. 38,2001–02, Performance Audit, Australia National Audit Office, Canberra, passim. Operation in the Middle East, see Commonwealth of Australia, 2004, *The War in Iraq—ADF Operations in the Middle East in 2003*, Department of Defence, Canberra, viewed 20 Sep 2004, <<http://www.defence.gov.au/publications/lessons.pdf>>, passim.
8. Commonwealth of Australia, 2003, *Australia's National Security—A Defence Update 2003*, Defence Publishing Service, Canberra, pp. 5–6.
9. For the ADF's future vision and warfighting concept, see Commonwealth of Australia, 2002, *ADDP-D.2—Force 2020*, Defence Publishing Service, Canberra, passim; and Commonwealth of Australia, 2003, *ADDP-D.3—Future Warfighting Concept*, Defence Publishing Service, Canberra, passim.
10. R. Hill, 2003, *Announcement of the Defence Capability Review*, transcript, press conference, 07 Nov, viewed 08 Apr 2004, <<http://www.minister.defence.gov.au/2003/ACF1C99.doc>>.
11. On 6 Sep 1999, Australia offered 2000 troops available to deploy at 48 to 72 hours notice. Three days later, the Australian offer was increased up to 4500 troops. In total, the ADF provided 5700 personnel to INTERFET, the largest Australian military deployment since the Vietnam War; see *Management of Australian Defence Force Deployments to East Timor*, pp. 9, 21–2 and 30.
12. *ADDP-D.2—Force 2020*, p. 14; and *ADDP-D.3—Future Warfighting Concept*, pp. 6–9.
13. While helicopters/tactical transports are not within the scope of this paper and is not specifically discussed, it must be noted that intra-theatre airlift is an integral part of a seamless rapid mobility capability. For general details of current ADF capability planning for intra-theatre/tactical airlift, see AIR 8000 and AIR 9000, Commonwealth of Australia, 2004, *The Defence Capability Plan 2004–2014—Public Version*, Defence Publishing Service, Canberra, pp. 51–62.
14. Commonwealth of Australia, 2003, *Defence Capability Review 2003*, statement, viewed 02 Apr 2004, <<http://www.minister.defence.gov.au/2003/14203.doc>>.
15. Commonwealth of Australia, 2003, *The Australian Defence Force—Capability Fact Book*, Defence Publishing Service, Canberra, pp. 34–5.
16. AIR 8000, see *The Defence Capability Plan 2004–2014—Public Version*, pp. 51–2; AIR 5401, see A. McLaughlin, 2003, 'RAAF Upgrades the C130H Hercules', *Australian Aviation*, Sep, No. 198, Aerospace Publications Pty Ltd, Fyshwick, ACT, pp. 26–7.
17. AIR 5402 is a \$2 billion project and the first aircraft is expected to be delivered in 2007, see R. Hill, 2004, *EADS/Qantas Wins Refuellers*, transcript, press conference, 16 Apr, viewed 17 Aug 2004, <<http://www.minister.defence.gov.au/2004/ACFA329.doc>>.
18. *The Australian Defence Force—Capability Fact Book*, p. 6.

19. JP 2048 Phases 4A, 4B and 4C are estimated to cost from \$1.65 billion to \$2.2 billion and the expected in-service delivery period of the three vessels is from 2012 to 2018, see *The Defence Capability Plan 2004–2014—Public Version*, pp. 86–8.
20. *Management of Australian Defence Force Deployments to East Timor*, pp. 12, 76–7 and 87; *The War in Iraq—ADF Operations in the Middle East in 2003*, p. 29.
21. The size of the amphibious ships planned under the DCP may be more than 20,000 tonnes. This is three times the size of the RAN's LPAs, currently the ADF's largest strategic lift assets. See *Announcement of the Defence Capability Review*; and Commonwealth of Australia, 2003, *Defence Capability Review 2003*, statement, viewed 02 Apr 2004, <<http://www.minister.defence.gov.au/2003/14203.doc>>.
22. S. Wilson, 2003, 'Airbus Military A400M', *Australian Aviation*, Aug, No. 197, Aerospace Publications Pty Ltd, Fyshwick, ACT, p. 41.
23. Tonne measurement is used throughout this paper. One tonne equals to 1000 kilograms or 2204.6 lbs.
24. The RAAF A330-200MRTTs will have significant cargo handling capability and will be configured to accommodate 293 troops; see G. Frawley, 2004, 'Airbus A30MRRRT', *Australian Aviation*, May, No. 205, Aerospace Publications Pty Ltd, Fyshwick, ACT, p. 36.
25. Providing enough tanking to support a fleet of 80–90 RAAF fighters requires around 20–30 A330 tankers, see C. Kopp, 2004, 'The Tanker Gap Remains—Five A330s Are Good, But Not Enough', *Australian Aviation*, Jun, No. 206, Aerospace Publications Pty Ltd, Fyshwick, ACT, pp. 32–3.
26. C4ISREW: Command, Control, Communication, Computer, Intelligence, Reconnaissance and Electronic Warfare.
27. P. Jackson, (ed.) 2004, *Jane's All The World's Aircraft 2004–2005*, Jane's Information Group Ltd, Surrey, UK, C-17 pp. 586–9, A400M pp. 239–241, and An-70 pp. 498–500.
28. Unit price as quoted in 2002; see V. Muradian, 2002, 'France Expresses Interests in C17 as Britain Seeks Two Additional', *Defence Daily International*, Apr 12, Vol. 2, No. 23, Phillips Business Information, Potomac, US, p. 1.
29. Wilson, loc. cit.
30. The United Kingdom is currently leasing four C-17s, with plans for leasing or outright acquisition of five more. Germany is leading a group of nations, including Norway, France and Canada, that is planning to lease C-17s to meet their short-medium term heavy-airlift needs; see R. Braybrook, 2003, 'Military Airlines', *Armada International*, Oct/Nov, Vol. 27, No. 5, Armada International AG, Zurich, p. 48.
31. All these problems were experienced in the ADF's operation in East Timor, see *Management of Australian Defence Force Deployments to East Timor*, pp. 76–7.
32. The recent Mobility Requirement Study 2005 (MRS-05) reported that the United States' airlift capability is falling short of requirement by a huge 9.8 million ton-miles per day, see A. Butler, 2004, 'TRANSCOM Chief: Pentagon Must Identify New Airlift Requirement', *Defence Daily*, Mar 11, Vol. 221, No. 45, Phillips Business Information, Potomac, US, p. 1. The European Union nations, including Britain, currently are all particularly weak on strategic airlift, see J. Dempsey, 2003, 'Italians Advance Case for Defence Agency Across', *Financial Times*, Jul 11, Financial Times Ltd, London, p. 7.
33. R.D. Carstens, 2003, 'New War Demands a New Military', *Proceedings—United States Naval Institute*, Dec, Vol. 129, No. 12/1210, United States Naval Institute, Annapolis, p. 2.
34. *ADDP-D.3—Future Warfighting Concept*, pp. 8–9.
35. J.A. Fellows, M.H. Harner, J.L. Pickett, M.F. Welch, 1996, 'Airlift 2025: The First with the Most', *Air Force 2025, Volume 2: Reach and Present*, Air University, Maxwell AFB, Alabama, viewed 18 Aug 2004, <<http://www.au.af.mil/au/2025/>>, pp. 43–4; and J. Edgell, S.J. Spangler, G.F. Dragoo, L.W. Jackson, 1996, 'Logistics in 2025: Consider It Done!', *Air Force 2025, Volume 2: Reach and Present*, Air University, Maxwell AFB, Alabama, viewed 18 Aug 2004, <<http://www.au.af.mil/au/2025/>>, p. 53.
36. B. Whitworth, 1998, 'High-tech Floats in an Old Guise', *Professional Engineering*, Jul 22, Vol. 11, No. 14, Mechanical Engineering Publications, Bury St. Edmunds, UK, pp. 35–6.
37. L. Hibbert, 2000, 'Inflated Ambition', *Professional Engineering*, Jul 19, Vol. 13, No. 14, Mechanical Engineering Publications, Bury St. Edmunds, UK, pp. 47–8.

38. Newer fabric for airship envelopes is much stronger, and more than 60% lighter than the envelope fabric used in older airships, see R. Wall, 2002, 'Interest Balloons in Military Blimps', *Aviation Week & Space Technology*, Nov 11, Vol. 157, No. 20, McGraw Hill Companies, New York, p. 55.
39. For more details on airship state-of-the-art technology, see Hayward, op. cit., pp. 15–17; and C. Pocock, 2000, 'Lighter-Than-Air, But Heavy With Promise', *Air International*, Nov, Vol. 59, No. 5, Key Publishing Ltd, Stamford, Lincs., UK, pp. 302–6.
40. Lockheed Martin Skunkworks, see Hayward, op. cit. pp. 11–12 and 50; Boeing Phantom Works, see *Jane's All The World's Aircraft 2004–2005*, p. 170.
41. Hibbert, loc. cit.
42. A Letter of Intent was signed with Boeing Phantom Works to consider the opportunities for the CL160 just before CargoLifter's insolvency, *Jane's All The World's Aircraft 2004–2005*, loc. cit.
43. SkyCat 1000's 1000-tonne lifting capacity is equivalent to that of ten Boeing 747s, see *Jane's All The World's Aircraft 2004–2005*, p. 508.
44. *ibid.*, pp. 507–9.
45. P. Almond, 2004, 'British troops are to go with a Thunderbird airship', *Sunday Times*, 12 Sep, London.
46. A. Atwood, 1997, 'The Battle Between the Blimp And The Sub', *Naval Aviation News*, Mar–Apr, Vol. 79, No. 3, Naval Historic Centre, Washington DC, pp. 26–9.
47. Airships do not have large metallic parts or large heat-emitting power plants, see Wall, loc. cit.
48. Hayward, op. cit., p. 26.
49. *ibid.*, pp. 22–3.
50. M.E. Rentell, 1998, 'Airship Set For A Comeback', *Interavia—Business & Technology*, Mar, Vol. 53, No. 618, Aerospace Media Publishing, Geneva, p. 38.
51. A SkyShip 600 operated at the Charles de Gaulle International Airport in Paris, and had impressed Air Traffic controllers of its manoeuvrability and its ability to fit into the airport's highly regulated air traffic environment. See T. Newton, 1997, 'Thoroughly Modern Airship', *Flight International*, 21–27 May, Vol. 151, No. 4575, Reed Business Information, Surrey, UK, pp. 34–5.
52. The modern airship only requires a ground crew of between three to 15 people, as compared to about 100 people for a pre-World War II airship, see Jeziorski, op. cit., p. 35.
53. Barnard, loc. cit.
54. Hayward, op. cit., p. 24.
55. Cook, loc. cit.
56. Hybrid airships use a combination of lift generators, the traditional helium and aerodynamic shaping of the envelope. The SkyCat uses a hybrid design, with 60% aerostatic lift generated from helium and 40% aerodynamic lift from aerodynamic shaping of the envelope. See Pocock, op. cit., p. 305.
57. C. Myers, Jr., 2003, 'HULA—A Helium Magic Carpet?', *Proceedings—United States Naval Institute*, Jun, Vol. 129, No. 6/1204, United States Naval Institute, Annapolis, p. 74.
58. For details of the draft ATD solicitation, see N. Shachtman (ed.), 2004, 'Darpa's U-Haul In The Sky', *Defence Tech*, 28 Jul, viewed 17 Aug 2004, <<http://www.defensetech.org/archives/001043.html>>.
59. G. Warwick, 2004, 'DARPA Details Plans for Ultra-Large Army Airships', *Flight International*, 11–17 May, Vol. 165, No. 4933, Reed Business Information, Surrey, UK, p. 28.
60. Pocock, op. cit., p. 306.
61. Myers, loc. cit.
62. Barnard, loc. cit.
63. Cook, loc. cit.

64. The seven broad functions C4ISREW include a very wide range of defence and security related tasks. The US, UK, Canada, South Korea and Japan are actively developing the High-Altitude Airship (HAA), an unmanned craft capable of a variety of C4ISREW tasks. South Korea already has a small operational HAA flying, providing a wide-area surveillance capability, see G. Marsh, 2004, 'Airship; Making a Comeback', *Aviation Today*, April, viewed 18 Aug 2004, <[http://www.aviationtoday.com/cgi/av/show\\_mag.cgi?pub=av&mon=0404&file=0404airships.htm](http://www.aviationtoday.com/cgi/av/show_mag.cgi?pub=av&mon=0404&file=0404airships.htm)>.
65. Commonwealth of Australia, 2004, *ADDP-D.3.1—Network Centric Warfare*, Defence Publishing Service, Canberra, passim.
66. There is indication in current Defence policy of the government's support for the US strategic missile defence program, see *Australia's National Security: A Defence Update 2003*, p. 17.
67. Hayward, op. cit., pp. 24–6.
68. 'Square-cube' law—when the dimension of an airship is doubled, its volume increases by a factor of eight. However, the surface area and power requirement (and therefore the main cost of construction and operation cost) only increase by a factor of four. As every cubic metre of helium can support another kilogram, the lift/cost ratio improves dramatically, Pocock, op. cit., p. 301.
69. Unit price as quoted in 2001, see *Jane's All The World's Aircraft 2004–2005*, p. 508.

## **Bibliography**

- Almond, P., 2004, 'British troops are to go with a Thunderbird airship', *Sunday Times*, 12 Sep, London.
- Atwood, A., 1997, 'The Battle Between the Blimp And The Sub', *Naval Aviation News*, Mar–Apr, Vol. 79, No. 3, Naval Historic Centre, Washington DC.
- Barnard, R., 2003, 'Iraqi Conflict Brings Interest in Military Airships', *Sea Power*, Jul, Vol. 46, No. 7, Navy League of the United States, Washington.
- Braybrook, R., 2003, 'Military Airlines', *Armada International*, Oct/Nov, Vol. 27, No. 5, Armada International AG, Zurich.
- Butler, A., 2004, 'TRANSCOM Chief: Pentagon Must Identify New Airlift Requirement', *Defence Daily*, Mar 11, Vol. 221, No. 45, Phillips Business Information, Potomac, US.
- Carstens, R.D., 2003, 'New War Demands a New Military', *Proceedings—United States Naval Institute*, Dec, Vol. 129, No. 12/1210, United States Naval Institute, Annapolis.
- Commonwealth of Australia, 2000, *Defence 2000—Our Future Defence Force*, Defence Publishing Service, Canberra.
- 2002, *Management of Australian Defence Force Deployments to East Timor*, The Auditor-General Audit Report No. 38, 2001–02, Performance Audit, Australia National Audit Office, Canberra.
- 2002, *ADDP-D.2—Force 2020*, Defence Publishing Service, Canberra.
- 2003, *Australia's National Security—A Defence Update 2003*, Defence Publishing Service, Canberra.
- 2003, *Defence Capability Review 2003*, statement, viewed 02 Apr 2004, <<http://www.minister.defence.gov.au/2003/14203.doc>>.
- 2003, *The Australian Defence Force—Capability Fact Book*, Defence Publishing Service, Canberra.
- 2003, *ADDP-D.3—Future Warfighting Concept*, Defence Publishing Service, Canberra.
- 2004, *The Defence Capability Plan 2004–2014—Public Version*, Defence Publishing Service, Canberra.
- 2004, *ADDP-D.3.1—Network Centric Warfare*, Defence Publishing Service, Canberra.
- 2004, *The War in Iraq—ADF Operations in the Middle East in 2003*, Department of Defence, Canberra, viewed 20 Sep 2004, <<http://www.defence.gov.au/publications/lessons.pdf>>.
- Cook, N., 1995, 'Giant Airships: Shifting the Load of the Future', *Jane's Defence Weekly*, Oct 28, Vol. 24, No. 17, Jane's Information Group Ltd, London.
- Dempsey, J., 2003, 'Italians Advance Case for Defence Agency Across', *Financial Times*, Jul 11, Financial Times Ltd, London.
- Edgell, J., Spangler, S.J., Dragoo, G.F., Jackson, L.W., 1996, 'Logistics in 2025: Consider It Done!', *Air Force 2025, Volume 2: Reach and Present*, Air University, Maxwell AFB, Alabama, viewed 18 Aug 2004, <<http://www.au.af.mil/au/2025/>>.
- Evers, S., 1996, 'Aerostats Offer Cruise Defence Solution', *Jane's Defence Weekly*, May 1, Vol. 25, No. 18, Jane's Information Group Ltd, London.
- Fellows, J.A., Harner, M.H., Pickett, J.L., Welch, M.F., 1996, 'Airlift 2025: The First with the Most', *Air Force 2025, Volume 2: Reach and Present*, Air University, Maxwell AFB, Alabama, viewed 18 Aug 2004, <<http://www.au.af.mil/au/2025/>>.
- Ferguson, G., 2004, 'RAAF Selects Airbus Tanker', *Australian Defence Magazine*, May, Vol. 12, No. 5, Yaffa Publishing Group Pty Ltd, Surry Hills, NSW.
- Frawley, G., 2004, 'Airbus A330MRRT', *Australian Aviation*, May, No. 205, Aerospace Publications Pty Ltd, Fyshwick, ACT.
- Hayward, K., 1998, *The Military Utility of Airships*, RUSI Whitehall Papers 42, Royal United Services Institute for Defence Studies, London.

- Heydt, B., 2003, '5th October 1930: The R101 Airship Disaster', *British Heritage*, Dec 2003/Jan 2004, Vol. 24, No. 7, Cowles Enthusiast Media, Harrisburg, UK.
- Hibbert, L., 2000, 'Inflated Ambition', *Professional Engineering*, Jul 19, Vol. 13, No. 14, Mechanical Engineering Publications, Bury St. Edmunds, UK.
- Hill, R., 2003, *Announcement of the Defence Capability Review*, transcript, press conference, 07 Nov, viewed 08 Apr 2004, <<http://www.minister.defence.gov.au/2003/ACF1C99.doc>>.
- 2004, *EADS/Qantas Wins Refuellers*, transcript, press conference, 16 Apr, viewed 17 Aug 2004, <<http://www.minister.defence.gov.au/2004/ACFA329.doc>>.
- Jackson, P., (ed.), 2004, *Jane's All The World's Aircraft 2004–2005*, Jane's Information Group Ltd, Surrey, UK.
- Jeziorski, A., 1995, 'Rigid Returns', *Flight International*, 29 Nov–5 Dec, Vol. 148, No. 4500, Reed Business Information, Surrey, UK.
- Kopp, C., 2004, 'The Tanker Gap Remains—Five A330s Are Good, But Not Enough', *Australian Aviation*, Jun, No. 206, Aerospace Publications Pty Ltd, Fyshwick, ACT.
- Lopez, R., 1995, 'Burning Ambition', *Flight International*, 29 Nov–5 Dec, Vol. 148, No. 4500, Reed Business Information, Surrey, UK.
- McLaughlin, A., 2003, 'RAAF Upgrades the C130H Hercules', *Australian Aviation*, Sep, No. 198, Aerospace Publications Pty Ltd, Fyshwick, ACT.
- Marsh, G., 2004, 'Airship; Making a Comeback', *Aviation Today*, April, viewed 18 Aug 2004, <[http://www.aviationtoday.com/cgi/av/show\\_mag.cgi?pub=av&mon=0404&file=0404airships.htm](http://www.aviationtoday.com/cgi/av/show_mag.cgi?pub=av&mon=0404&file=0404airships.htm)>.
- Muir T., Haddock, F., 2003, 'The Royal Australian Air Force Facing the Future', *Military Technology*, Feb, Vol. 27, No. 2, Moench Verlagsgesellschaft mbH, Bonn.
- Muradian, V., 2002, 'France Expresses Interests in C17 as Britain Seeks Two Additional', *Defence Daily International*, Apr 12, Vol. 2, No. 23, Phillips Business Information, Potomac, US.
- Myers, C. Jr., 2003, 'HULA—A Helium Magic Carpet?', *Proceedings—United States Naval Institute*, Jun, Vol. 129, No. 6/1204, United States Naval Institute, Annapolis.
- Newton, T., 1997, 'Thoroughly Modern Airship', *Flight International*, 21–27 May, Vol. 151, No. 4575, Reed Business Information, Surrey, UK.
- Pike, J., 2003, 'High Altitude Airship (HAA)', *GlobalSecurity.org*, 21 Dec, viewed 17 Aug 2004, <<http://www.globalsecurity.org/intell/systems/haa.htm>>.
- Pocock, C., 2000, 'Lighter-Than-Air, But Heavy With Promise', *Air International*, Nov, Vol. 59, No. 5, Key Publishing Ltd, Stamford, Lincs., UK.
- Rentell, M.E., 1998, 'Airship Set For A Comeback', *Interavia—Business & Technology*, Mar, Vol. 53, No. 618, Aerospace Media Publishing, Geneva.
- Royal Australian Air Force, 2002, *AAP1000—Fundamentals of Australian Aerospace Power*, fourth edition, Aerospace Centre, RAAF Base Fairbairn, ACT.
- Shachtman, N. (ed.), 2004, 'Darpa's U-Haul In The Sky', *Defence Tech*, 28 Jul, viewed 17 Aug 2004, <<http://www.defensetech.org/archives/001043.html>>.
- Sherman, K.B., 2003, 'US Navy Testing LASH on Airships', *Journal of Electronic Defence*, Oct, Vol. 26, No. 10, Horizon House Publications, Norwood, US.
- Stibbe, M., 2004, 'Defence Inflation: Meet the Homeland Security Blimp, Flying High by 2006', *Popular Science*, Feb, Vol. 264, No. 2, Time Inc, New York.
- Tirpak, J.A., 2003, 'The Squeeze on Air Mobility', *Air Force Magazine*, Jul 2003, Air Force Association, Arlington, US.
- Wall, R., 2002, 'Interest Balloons in Military Blimps', *Aviation Week & Space Technology*, Nov 11, Vol. 157, No. 20, McGraw Hill Companies, New York.

- Warwick, G., 2004, 'DARPA Details Plans for Ultra-Large Army Airships', *Flight International*, 11–17 May, Vol. 165, No. 4933, Reed Business Information, Surrey, UK.
- Weaver, L., 2003, 'Task Force Concepts Of Operations—Transforming The USAF', *Air & Space Power Journal*, Summer 2003, Vol. XVII, No. 2, Air University, Maxwell AFB, Alabama.
- Whitworth, B., 1998, 'High-tech Floats in an Old Guise', *Professional Engineering*, Jul 22, Vol. 11, No. 14, Mechanical Engineering Publications, Bury St. Edmunds, UK.
- Wilson, S., 2003, 'Airbus Military A400M', *Australian Aviation*, Aug, No. 197, Aerospace Publications Pty Ltd, Fyshwick, ACT.



