Asset Management of an Ageing Aircraft Opportunities Lost and Wins Achieved

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Summary: The 30 year-old S-70A-9 Black Hawk helicopter is an ageing aircraft, exhibiting many of the physical and logistics support characteristics of a mature weapon system. Army Aviation Systems Program Office[1] has sustained the Black Hawk fleet by applying a 'traditional' model, a continuation of the Weapon System Logistics Management construct established by Support Command - Air Force in the early 1990s, and it remains one of only a few Australian Defence Force aircraft managed under this support construct. The Program Office's activity has matched the changes in fleet-size, operating bases and level of effort and training required by the operational tempo. As the Black Hawk nears withdrawal from service, the realised performance of the capability as captured in aircraft and logistics records, and interviews with long-serving staff, are analysed to consider whether support to this National Asset has been appropriate. Referencing from a contemporary standards - ISO5500x:2014: *Asset Management* – retrospective consideration of the realised capability for what could have been a better outcome of greater aircraft availability, increased rate of effort, more efficient resource utilisation, and lesser cost of ownership is undertaken for three distinct phases of the Black Hawk's in-service life.

Keywords: Asset Management, Ageing Aircraft, Aircraft Management, Army Aviation.

Introduction

Asset management is a relatively recent 'international standard', growing from the British Standards Institution (BSI) Publicly Available Specification (PAS) 55:2004 and most recently promulgated as ISO5500x:2014: *Asset Management*, is on the cusp of being utilised within the Australian Defence Force (ADF) for sustainment management by the Capability Acquisition and Sustainment Group (CASG) across the three environments[2], starting with aerospace. The standard is a relatively dry affair, with the richness of intent better appreciated from general education works authored in the UK by The Institute of Asset Management (IAM) and the *Asset Management Body of Knowledge* published by the Australian Asset Management Council.

The Australian S-70A-9 Black Hawk has been in service since 1988; the operational fleet is close to completing re-sizing – from two squadrons in Townsville and a training element at Oakey, to a single squadron operating in Sydney – as planned withdrawal in the early 2020s approaches, having flown over 200,000[3] flying hours and deployed on multiple overseas and domestic operations. Sustainment for the Black Hawk fleet has been managed by Army Aviation Systems Program Office (AASPO), using a traditional Weapon System Logistics

[1] Support to the fielded aircraft originated with the Project Air 5046 initial 24 month interim support arrangement with Sikorsky International Operations Inc (SIOI) that covered the two calendar year 1998-1989, transitioning to stove-piped engineering, supply and repairable units within in Support Command – Air Force, before the formal commencement of in-service management by Army Aircraft Logistics Management Squadron, newly formed under the Weapon System Logistics Management philosophy.
[2] Maritime, Land and Air.
[3] Achieved Sep 2017.

Management (WSLM) approach, performing weapon system integration with organic design engineering, project management, logistics and business support capabilities.

The paper is a retrospective consideration of the 'as experienced' Black Hawk in-service sustainment – management philosophy, policy and priorities – viewed through the contemporary paradigm of Asset Management, adapting a bank of questions developed by CASG for implementing the new Standard. The research supporting this paper is thirty years of management records, performance data and selected stakeholder interviews, collated to create a time-line matrix of; capability events, Fundamental Inputs to Capability, logistics, financial, personnel and other historical management initiatives, subsequently analysed in isolation and across streams, and chunked into emerging 'asset management like' practices. Matching the performance timeline (effects) to what were the evolving and emerging asset management-like competencies (causes) reveals where 'game changing' management practices did, or could have, made a difference to the Black Hawk capability's performance.

Asset Management

Any assessment of the three decades of Black Hawk sustainment needs to couch the then contemporaneous Support Command, Defence Materiel Organisation (DMO) and early CASG practices in light of the current Asset Management philosophy, an exercise of translation.

Asset Management for the Air Domain

Reviews[4] into Defence sustainment over 2010-11 highlighted that Asset Management – as envisaged by the British PAS55 for 'physical' assets – applied as a systemic approach for sustainment within the DMO, was lacking. The summative brief to DMO Division Heads in September 2011 advised of four shortfalls as a consequence: Lack of a holistic asset management view; lack of "hard" governance based on management decisions, financials and across the forward capability lifecycle; loss of asset management information configuration control; and, inconsistent and fractured information [knowledge] sharing. DMO's consideration of ISO 55000 in late 2012[5] concluded that;

> *… the decision regarding the desirability of adopting a compliance and assurance program linked to these [ISO 55000] standards is yet to be determined … [and] … it is currently not seen as desirable that government legislate to make application of the Standards mandatory …* [but suggesting] *… it is likely that in some highly regulated areas, involving significant asset values, the regulators may look to the comfort of requiring these [ISO 55000] Standards to be applied, to protect their interests …* [and recognising that] *… The Requirements part of the Standards are very much about the "what to do" in establishing [a Management System] and not about "how to do it".*

In late 2014 the Sustainment Management Professionalisation and Certification Framework for use by Australian Defence Organisation employees drew upon ISO55000, and CASG subsequently promulgated the use of the Standard in the 2016 Interim Capability Life Cycle Manual. Most recently, the CASG released their Product Management Manual[6] which reaffirms 'CASG's management of Defence Products through the application of asset management principles described in AS ISO 55000-55002:2014 Asset Management

[4] Helmsman Review, Rizzo Review and Coles Review as cited in Commonwealth of Australia, Australian National Audit Office, *Defence's Management of Materiel Sustainment*, 2017, Section 5.58 and Appendices 5 and 6.
[5] *Implications of ISO 55000 Standards for Asset Management in DMO*, late 2012, cites PJ Way's 2012 '*Implications of ISO 55000 Standards for Asset Management'* as the source.
[6] Capability Acquisition and Sustainment Group Manual- *CASG Product Management Manual*, Version 1.0, August 2018, sub-para 10d concludes with; 'for the purposes of this manual, the terms Product and Asset may be used interchangeably.'

Standards.' The Manual covers matters of leadership, utilisation of Centres of Expertise (CoE) and groups providing Fundamental Inputs to Capability (FIC), planning over the life cycle, integrated sustainment management, and performance, thereby adding Australian Defence context to the Standard, and reinforcing the "what to do" with "how to do it" referred-off to the program, engineering materiel logistics and commercial CoE.

The genesis of the three ISO 5500X 'generic' Asset Management standards released in 2014 is the British PAS55 for 'physical' Asset Management, first published by the BSI in 2004 and updated in 2008. These dates overlap with DMO and CASG sustainment practices, enabling translation from ISO55001, through PAS55 to contemporaneous practices in the early 2000 (and earlier given the longevity of some management practices used in the aerospace sector). The architects of PAS55 caution the reader[7];

> *It is important to understand that the 39 Subjects describe the body of Asset Management knowledge as a whole, whereas PAS55 is a [28] requirements checklist for an organisation's management system – to direct, control and continually refine Asset Management. This will become even more formal and explicit with the planned publication in 2014 of ISO55000/1/2. Please note, therefore, that learning about the management system standard alone does not constitute knowledge and competence across Asset Management as a whole! … for … master[ing] the discipline, knowledge of PAS55 and … ISO55000 is important but not the whole picture – you really need to learn the whole discipline as represented by the 39 subjects … [to the] level and degree depending upon you area of responsibility or operational environment.*

With the promulgation of the ISO 55000 standard, IAM up-issued their literature[8], mapping the Body of Knowledge (BoK) 39 subjects to the clauses of ISO 55001:2014.

Air Domain – consisting of CASG's Aerospace Systems Division, Helicopter Systems Division and Joint Strike Fighter Division – has taken steps to provide context to the generic Standard for Defence context; interpreting and operationalising ISO55000, reinforcing the approach of managing aviation for specific risks and technology, defining the boundary of the 'asset' by all actions performed to realise a capability, and emphasising the understanding of the (asset) value to be obtained by integration of these actions across all contributors[9]. This work, quite naturally utilises proven practices, drawing upon the underpinning approaches of systems engineering, alludes to ageing aircraft management informed by reliability analysis, and on-going cost of ownership management over the life cycle, for a goal of 'avoiding surprises' as Air Domain sustainment delivers asset management operations; and at a governance level, equates 'asset management' with 'capability assurance'. What is 'new' is the extended Work Breakdown Structure (WBS) that expands upon the traditional FIC elements[10] by considering the multiple sub-programs that constitute a capability (asset), which harks back the fundamental question as to 'what are the elements (actions) that define the asset?', but also lifts the view of 'asset management', within Defence, from the 'tactical' to the 'strategic' along with meeting the complexity that entails for the many gaps in extant management systems that are fragmented within Defence and do not straddle the industry support-base[11]. At the same time, an Aircraft Asset System WBS – very much the 'physical asset' that constitutes the 'Major Systems' element of the previously described FIC-based WBS, and tailored for the specific (airframe, propulsion, mission systems, integration and

[7] The Institute of Asset Management, *Asset Management – an anatomy*, Version 1.1, February 2012, p2. The primer lists the 39 Subjects, under six Subject Groups on p17, and depicts how the six Subject Groups interact in their conceptual model at p16.
[8] The Institute of Asset Management, *Asset Management – an anatomy*, Version 3, December 2015, Appendix A.
[9] Presentations from GPCAPT Adrian Morrision, at the Aircraft Airworthiness and Sustainment Conference, Brisbane, July 2018, and codified as a 'Defence Aviation Asset Management Manual'
[10] Organisation, Command and Management, Personnel, Collective Training, Major Systems, Facilities and Training Areas, Supplies, Support, Industry.
[11] Morrision, A., Defence Aviation Asset Management Project – Initial Brief to Steering Group February 2018, Version 3.0, April 2018. Initiatives, such as *House of Governance*, utilising *Holocentric*, is intended to consolidate Defence practices.

configuration) attributes of the platform – is nested as one of the 'equipments' that make a 'sub-program' that realise a 'capability'. This complexity replicates reality and can only be simplified so far without 'dumbing-down' the model to a level of ineffectively or worse; failure to manage the 'whole' capability, results in second and third-order consequences, unforeseen (surprises!), and inappropriate actions taken from ignorance or failure to understand 'cause and effect' temporal relationships between WBS elements. Air Domain has proposed twelve 'key asset management questions'[12] – paraphrased in Table 1 – to gauge the status quo.

	Question
1	Effective system of (asset) management?
2	Asset properly identified and characterised?
3	(asset) management strategy in place for system and each system element?
4	(asset) management responsibility assigned?
5	Demand (requirement) defined and analysed?
6	Understanding of Total Cost of Ownership based on sub-system cost attribution?
7	Supportability analysed?
8	System condition, performance, cost and life-consumption trends tracked and analysed?
9	Implementing ILS[13] practices that prevent or reduce decay and cost?
10	Risks identified, acted-upon and reported?
11	Strategic (asset) management risks identified and reported?
12	Opportunities sought, proposed and implemented?

Table 1 – Key (asset) Management Questions

These questions are 'outcome focused', and should, if right, be enduring in their Defence context. If so, they represent a 'management' question set that can be applied retrospectively for consideration of (pre-ISO) asset management-like practices, as well as for assessing on-going asset management maturity in applying the Standard by ascertaining whether, at the macro level, the attribute is; present, suitable, operating and effective.

The assessment of each macro attribute is supported by consideration as to whether, and to what degree, any of PAS55's 39 Subjects – the BoK touchstones – are contributing. The completeness of this BoK centric micro-view can be roughly gauged by placing Air Domain's twelve *Asset Management Questions* onto IAM's 2015 mapping of 'physical' asset management to the ISO's 'generic applicability' Standard. As depicted below, in Figure 1, completing the activity for *Question 9 Implementing ILS practices that prevent or reduce decay and cost?* by selecting BoK subjects contribute to this question, creates a heat map for each query.

[12] Morrision, A., *op. cit*. In paraphrasing, the use of the term 'asset' has been limited to the physical; 'Asset Management' is a defined phrase by the Standard, so whilst historic practices, pre-dating the Standard, were not intended to meet this benchmark, they can still be considered as to whether they represented sound 'Management' practices.
[13] Integrated Logistics Support

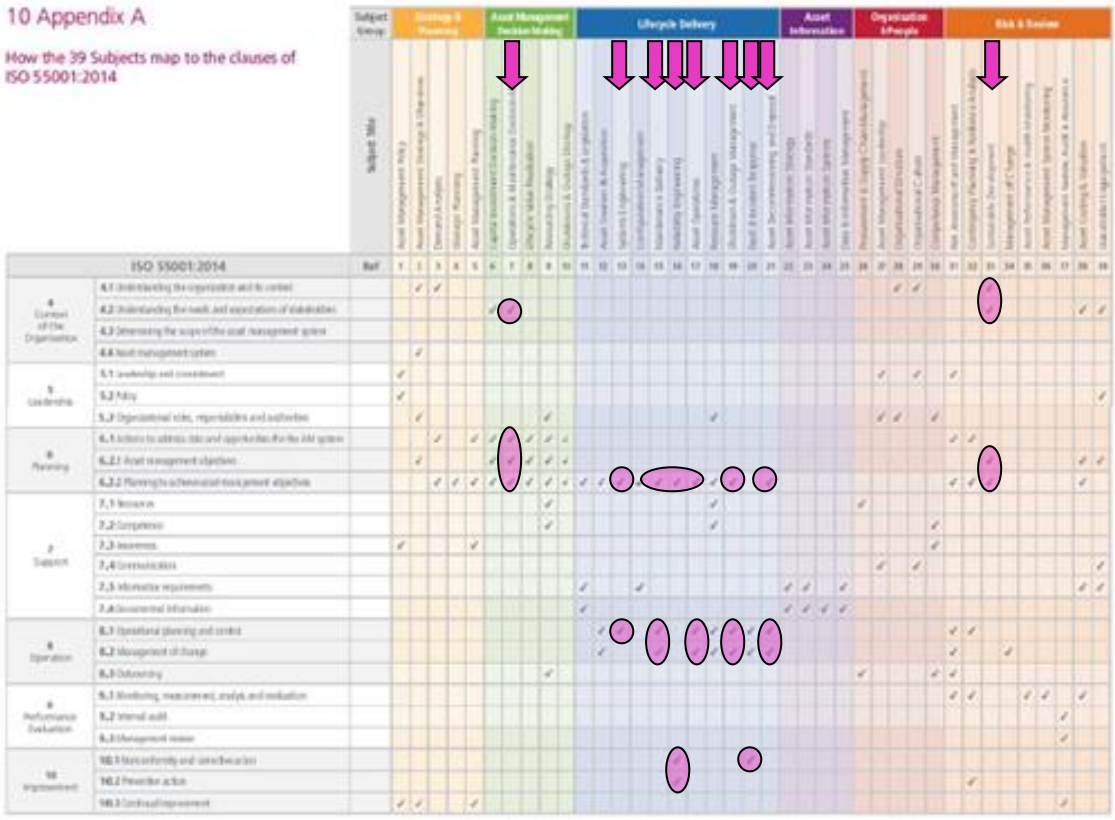


Figure 1 – Asset Management BoK Subject Groups relevant to *Implementing ILS Practices*

Completing this activity for all twelve questions, Figure 2, shows that the twelve individual heat maps have a high degree of coverage of the matrix tick boxes (attributed 'heat bubble/s' generated from each question 'arrow' excluded for clarity), with the notable exception – as marked by the red ring - being the BoK's *Asset Information* subject group, which in turn has a correlation to ISO 55001's Section 7.5 *information requirements* and Section 7.6 *documented information*, as marked by the red dashed ring.

Perhaps, overarching CASG's twelve questions, is the unstated capstone issue – that would be a thirteen question – that also captures these missing attributes; 'Are these twelve matters being considered in splendid isolation (in context or time), or are they synchronised, namely: Is the (asset) management activity integrated?'.

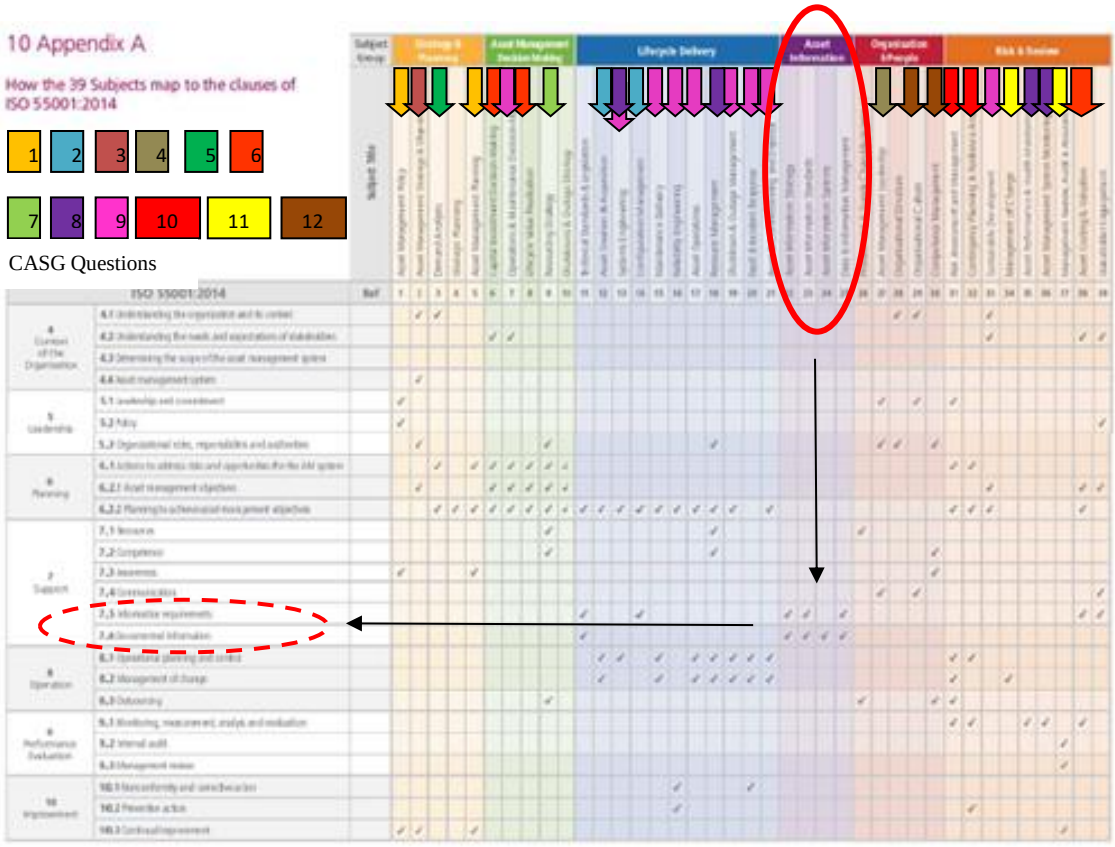


Figure 2 – Asset Management BoK Subject Groups relevant to the Twelve Questions

For a long-operating physical asset, such as the Black Hawk helicopter within the Army aviation capability, with a substantial body of programmatic data available to analyse, differing periods of management should be evident if management activity has resulted in changed (from the physical asset perspective) capability performance.

Asset Management Success?

What does the Asset see – its perspective of 'being managed' is what? – as success? Close to the top in the hierarchy for aviation performance management is Rate of Effort (ROE) (see Figure 3); flying hours generated by having the right resources in the right place to effect flight, only surpassed by the mission outcome(s) from that flight achieving or contributing to preparedness or level of capability. Sound aviation management is characterised when fly to plan/plan to fly equilibrium is maintained, concurrent with; capability development, re-organising, deploying, operations and changing supportability: A reliable capability is based on a supportable and supported aircraft weapon system.

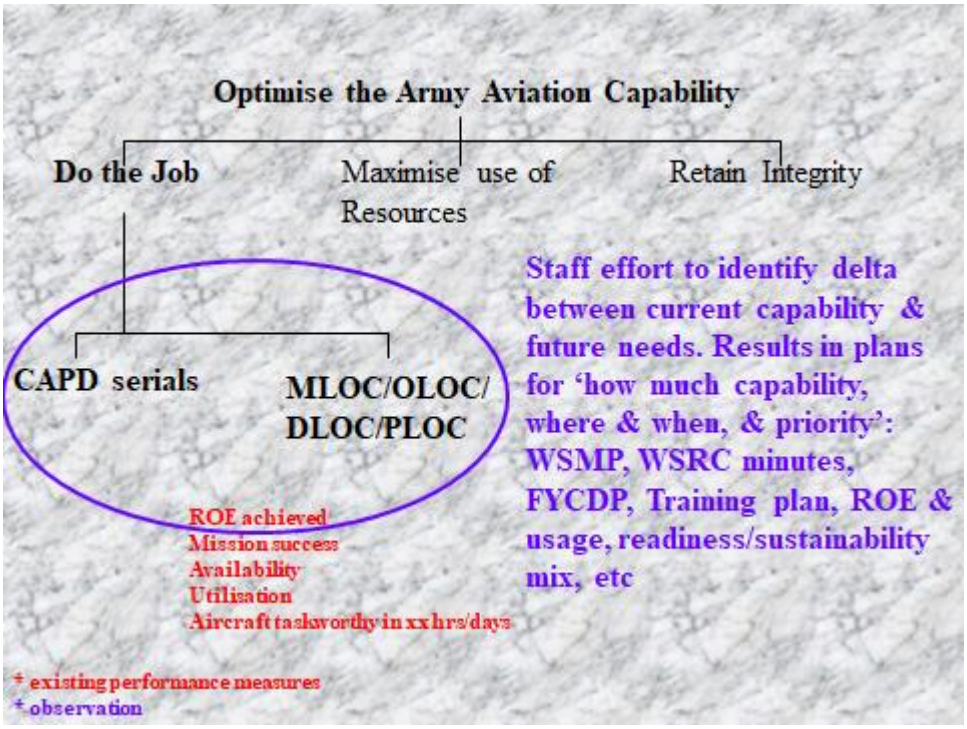


Figure 3 – ROE as a Dominant Performance Measure[14]

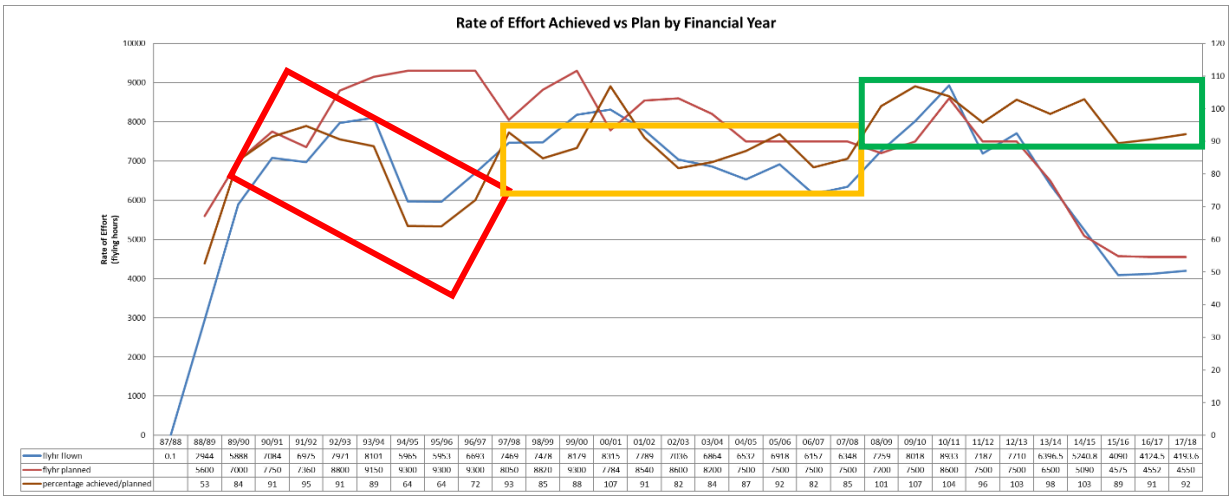
The 'plans' are cumulative and can be, when elements are synchronised, positively reinforcing; daily and weekly flying program success leads to annual ROE success (generating individual aircrew and collective military force competencies, without compromising preparedness). A string of annual ROE achievement, accommodating fleet management changes for capability upgrades and meeting calls on preparedness, with periodic adjustment in industry support-base, builds confidence in the collective ability to respond to (operational and logistics) change, and optimises future planning (with less allocation contingency – capability brick, time, redundancy, cash – and cunning contingency responses). Repeatedly achieving ROE, from a relatively consistent cost base, without compromising capability integrity would indicate a period of better asset management leading up to, and during that time.

Based on the metric of *meaningfully achieving planned rate of effort over sequential years* Figures[15] 4 and 5 show three distinct phase ('boxed' for repeated plan performance within bands, and 'arrowed' for funding stability) for the Black Hawk capability:

- 1988 to mid-1990s - Introduction into Service. During this period the ROE progressed toward the planned 9300 flying hours annual target but stalled in Financial Year (FY) 94/95 as the insufficient funding base from previous years manifested, without ever achieving that flying hour figure. In the process, the fleet operated beyond the logistic capacity established for the capability – exceeding sustainment funding, and stressing the immature domestic industry and military on-aircraft maintenance and repairable item support-base - denuding the logistics supply system pipeline of repairable stock, creating a challenging base from which to recover the capability. A significant allocation of funds in FYs 93/94 and 94/95 were not immediately effective due to the under-primed repairable item pipeline and turnaround time to the American industrial support-base. The Board of Inquiry into the 1996 fatal crash of A25-113 and A25-209 identified poor aircraft availability as a contributory factor to the accident[16]. The Black

[14] Campbell J. and Crowe R. B., *Army Aviation Capability Performance Framework*, Slide 4, 2004
[15] Based on data drawn from Defence Annual Reports and fleet management records.
[16] Black Hawk Board of Inquiry, sub-paragraph 4.37 m, 'Contributory cause … reduction in aircrew proficiency levels as a consequence of a shortage of serviceable aircraft during 1994 and 1995.'

Hawk capability had generated a significant logistics liability, utilising all serviceable stocks but without the funding surety to induct unserviceable items for repair, resorting to regular cannibalisation, and fully utilised all but a few thousand dollars of the in-year budget to meet outstanding commitment from previous financial years.



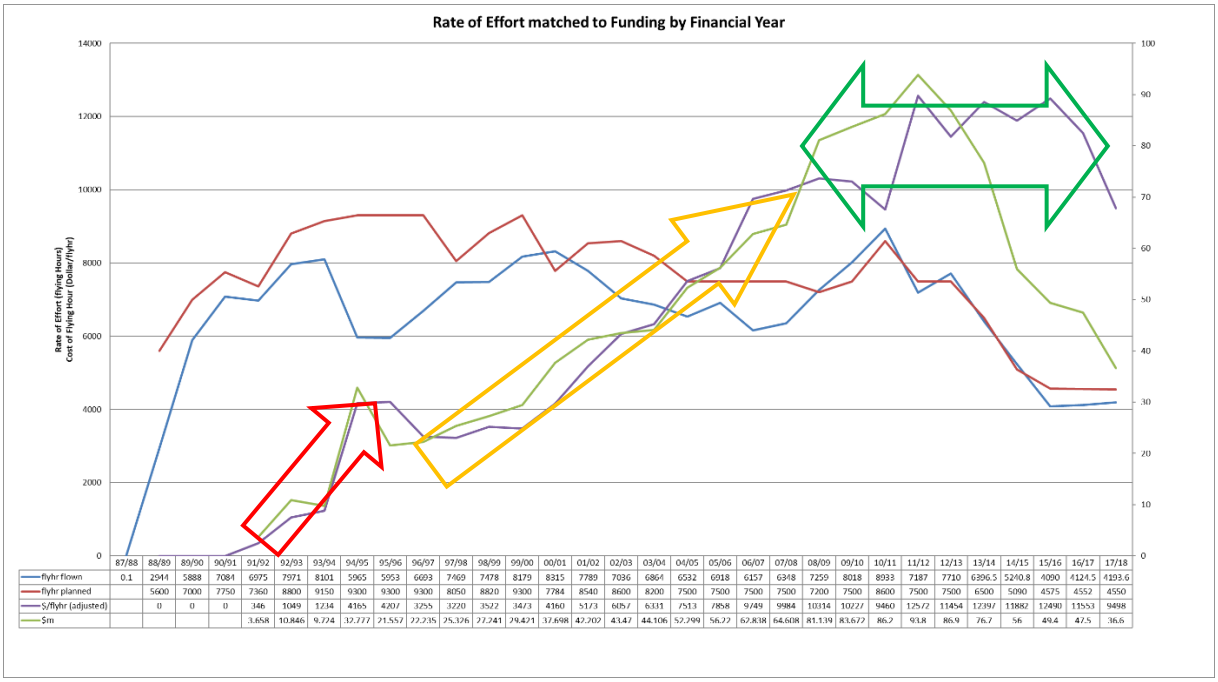
	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
flyhr flown	0.1	2944	5888	7084	6975	7971	8103	5985	5953	6693	7469	7478	8179	8315	7789	7016	6864	6537	6918	6157	6148	7759	8018	8933	7187	7710	6396.5	5240.8	4090	4124.5	4193.6
flyhr planned		5600	7000	7750	7360	8800	9150	9300	9300	9300	8850	8800	9300	7784	8540	8800	8200	7500	7500	7500	7500	7200	7500	8600	7500	7500	6500	5080	4575	4557	4550
percentage achieved/planned		53	84	91	95	91	89	64	64	72	93	85	88	107	91	82	84	87	92	82	85	101	107	104	96	103	98	103	89	91	92

Figure 4 – ROE Achieved vs Plan[17] by FY – Stability over Successive Years

- Mid-90s to mid-2000s – Capability Recovery. During this decade a more realistic management, varying ROE being proposed, and matched with a (relatively) significant continuing investment in the logistics support system, resulted in some year-to-year consistency in supporting the planned flying at 80 percent or better, but lacked certainty and stability for the funding base – considered from the perspective of dollars per flying hour –and was still building from a low of $3000 per flying hour to nearly $10000 over the ten years, resulting in 'scarce' funding being prioritised, but without achieving equilibrium within commodities and across elements of the support system.

- Late 2000s to present – Capability Delivery. During this decade ROE was matched with consistent investment, in the $10-12000 per flying hour range, resulted in year-to-year consistency for supporting the planned flying at 90 percent or better. The capability established the resource and logistics basis to remain 'on plan' , and had sufficient capacity to recover from unplanned overfly events in back-to-back FYs, unlike during the previous phase with the surge at the turn of the century associated with Operations in Timor Leste and the Sydney Olympics.

[17] The planned ROE in FY 88/89 is taken from the Project ILSP, Section 8.3.1 which set the plan against an operational requirement of '5600 flying hours for fourteen aircraft'; the 'mature' ROE for the fleet, from 1995 onwards was set at an enduring 9300 flying hours (flyhrs) [*Brief for CofS and DGMM HQ Log Comd on Aircraft Availability/Serviceability for One star Meeting to Discuss this Problem at 5 Avn Regt on 17 Jul 91*]. The ROE in the period between FY90/91 and 93/94 is provided by in Annex A to Enclosure 1 of the Headquarters Logistics Command – Air Force's October 1994 *RAAF Support to Army Aviation*, colloquially known as the Zerate Report. FY88/89 and FY 90/91 are interpolated values, as definitive values could not be found. FY 99/00 has been discounted to 9300 flying hours (the previous benchmark) on the basis of the Annual Report which stated; 'Under contingency planning for East Timor, the Black Hawk, [Iroquois, Kiowa, and King Air] aircraft were allocated additional flying hours in the additional estimates. The anticipated increase in the rate of effort did not eventuate as training requirements were able to be achieved concurrent with East Timor operational duties.' The mid 2005 *AASPO A25 Brief to COMD 16 Bde (Avn),* states that the Materiel Sustainment Agreement approved ROE as 8600 flyhrs, but the 'revised approved' figure was 7500 flyhrs. The 2009 Airworthiness Board submission states that the planned ROE for FY08/09 was 7200 flyhrs.



	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
flyhr flown	0.1	2944	5888	7084	6975	7971	8101	5965	5953	6693	7469	7478	8179	8315	7789	7036	6864	6532	6918	6157	6348	7259	8018	8933	7187	7710	6896.5	5240.8	4090	4124.5	4193.6
flyhr planned		5600	7000	7750	7360	8800	9150	9300	9300	9300	8050	8820	9300	7784	8540	8600	8200	7500	7500	7500	7500	7200	7500	8600	7500	7500	6500	5090	4575	4552	4550
$/flyhr (adjusted)		0	0	0	346	1049	1234	4165	4207	3255	3220	3522	3473	4160	5173	6057	6331	7513	7858	9749	9984	10334	10227	9460	12572	11454	12397	13882	12490	13553	9498
$m					3.658	10.846	9.724	32.777	21.557	22.235	25.376	27.241	29.421	37.698	42.202	43.47	44.106	52.599	56.22	67.838	64.608	81.139	83.672	86.2	93.8	86.9	76.7	56	49.4	47.5	36.6

Figure 5 – ROE Achieved vs Plan by FY – Expended Funds/Flying Hour Stability

Black Hawk performance, looked at from this higher level, reveals differences in 'asset management' outcomes for three periods over the last 30-years, each phase expected to be driven by different issues, that can be examined for prevailing asset management themes.

(Asset) Management Themes - by Phases - for Black Hawk

Management of the Black Hawk weapon system, in the context of delivering capability as required by the Material Sustainment Agreement (MSA), then later, Product Schedule (PdS) and Product Management Program (PMP) agreements, is viewed in three phases of; Introduction to Service, Capability Recovery, and Capability Delivery. Notionally, each is about a decade long, though the initial activity of consuming the fleets flying 'bank' hours and logistics resources is markedly shorter than the subsequent period required to bring the capability back into a balance, and thence onto creating the solid (asset) management basis for reliably delivering sustained flying demonstrated by current tasking.

Introduction into Service

Sound conditions for asset management were not established during acquisition, which went beyond the materiel supply and management arrangements for the S-70A-9 Black Hawk acquisition and fielding, with the tensions that remained from the decision to transfer the battlefield helicopters from the RAAF to Army[18];

> *There were also serious discontinuities in the logistics support arrangements associated with the transfer [of the Black Hawk from RAAF to Army]. The RAAF remained responsible for the provision of logistics support, but there seems to have been inadequate management of the process, with, for example, the spares provisioning not matching the Army's flying rate. The lack of adequate budgeting arrangements between the RAAF and the Army for Blackhawk (sic) spares may have compounded the problem, for while RAAF was responsible for resourcing and provisioning spares for Army aircraft, the Army had no visibility of the RAAF's expenditure or control over allocations. Managing logistics support for new aircraft*

[18] Sharp, M., Airpower Studies Centre, *Command and Control of Battlefield Helicopters: The Search for a Joint Approach*, Canberra 1998, pp87-89

can often be a difficult process, especially across two Services, but the atmosphere of sourced inter-Service relations would certainly not have helped matters.

Whilst the last aircraft was delivered 14 months behind schedule[19], the realisation of a 39-helicopter strong fleet was rapid, as shown in Figure 6, with the only decline being the loss of five aircraft over the first two decade due to attrition from four accidents[20].

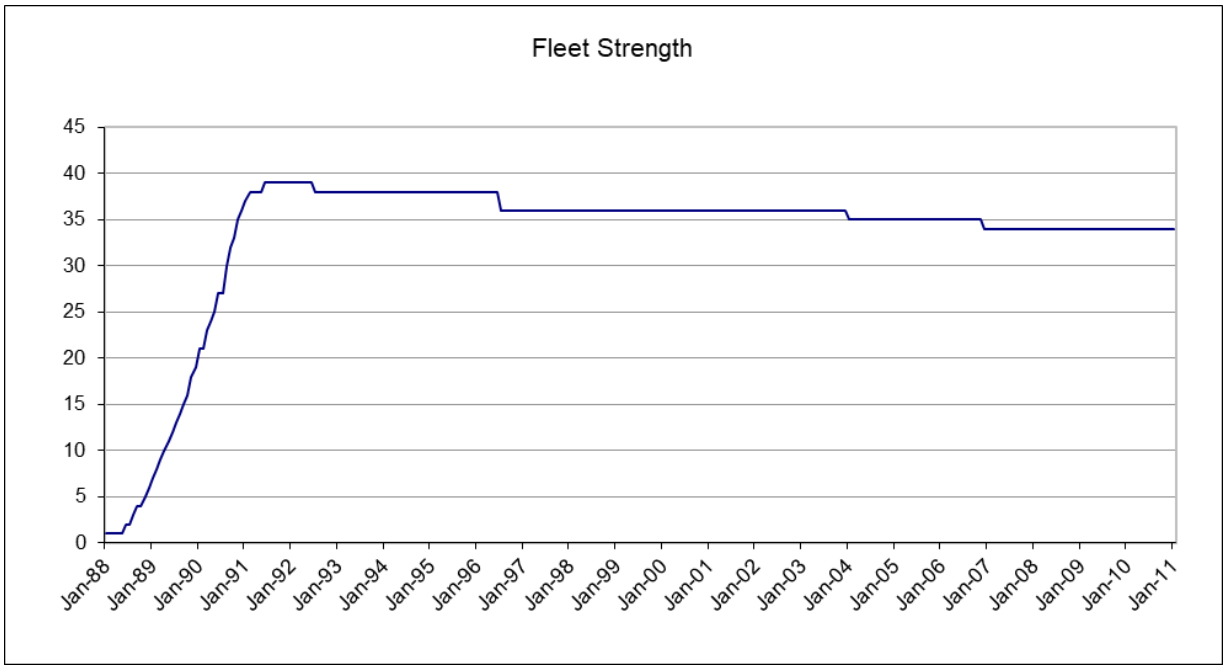


Figure 6 – Rate of Introduction to Service and subsequent Fleet Attrition

Significant Airframe Hours (AFHRS) were accrued by the first few aircraft through 1988-1989 given the small fleet size available to meet acquisition-related tasking, Figure 7, but then as the full fleet took up the flying liability of two Squadrons at 5th Aviation Regiment (5 Avn Regt) and a training element at Oakey, a pattern formed that remained representative for the following 30-years, flying remaining in a band of 10-25 AFHRS per aircraft per month.

[19] Department of Defence, Project Air 5046 Phases 1 and 2 – *Black Hawk Utility Helicopter Project Closure Report*, 2000; Phase 1 was approved for 14 helicopters and Phase 2 for a further 25 helicopters. The first aircraft (A25-101) was delivered on 31 Dec 87 (scheduled September/October 1987), and the 39th (A25-201) on 26 Jan 91 (originally scheduled June 1988, but only 14 months based on a renegotiated schedule).

[20] A25-217 near Oakey on 29 June 1992 with two fatalities; A25-113 and A25-209 at High Range Training Area on 12 June 1996 with eighteen fatalities; A25-216 near Mt Walker on 12 February 2004; and A25-221 on HMAS Kanimbla off Fiji on 29 November 2006 with two fatalities. This has proved much better than the Director Operational Analysis – Air Force's estimate of sixteen Category 5 helicopters over a 20 year Life of Type for a fleet of 44 aircraft (updated in 1986 based on the latest US Army attrition data from the original of 1984), or the revised estimate made in 1987 by DSTO being 14 attrition aircraft for 240000 flying hours, and ultimately negated by limiting the Phase 2 buy to 25 helicopters and not approving Phases 3A and 3B (together amounting to a further 19 helicopters).

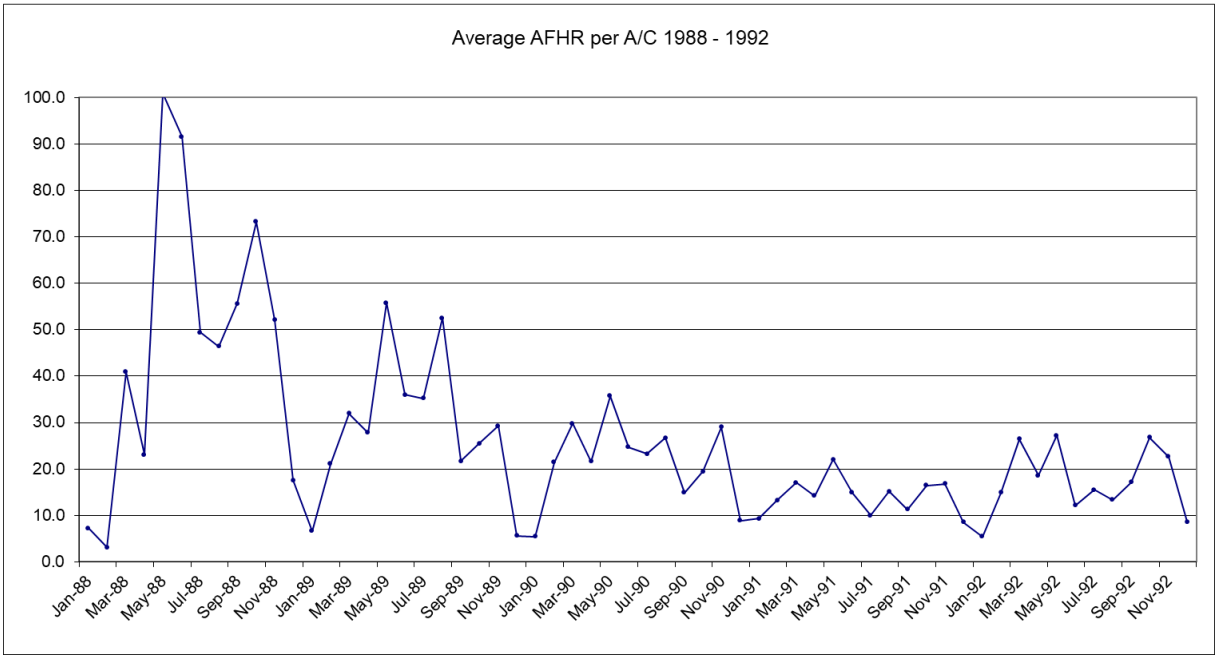


Figure 7 – Average Flying Hours per Aircraft at start of Introduction to Service

Information for this early period is drawn primarily from sources that have summarised the situation as they had analysed it – Logistics Command-Army[21], the Australian National Audit Office, and the Project Air 5046 Project Closure Report – and whilst some sources had the benefit of significant hindsight, the record of sustainment challenges during this period are consistent in describing the weaknesses in the prevailing management system:

- 1991 Logistics Command-Army briefing identified the following problems that affected availability at that time:
    - Flying rate coupled with relatively low level of logistics support – significant support deficiencies[22] remaining despite imminent Project Air 5046 closure – producing a backlog of ten aircraft awaiting major servicing[23].
    - Significant increase and technology, not matched by rapid influx of experienced manpower[24].
    - Operators yet to realise that capacity of logistics support arrangements is the limiting factor in setting and achieving flying rates, not authorised ROE.
    - Additional strain on logistics support from UH-1H Iroquois transferred in a poor state of repair and a high percentage requiring major servicing.
    - Outstanding modification program[25] envisaged to impact [future rate of] role development.
    - Major problem with repair parts being their long lead times; breakdown spares being three to six month lead-time, major items as long as two years.

[21] Department of Defence, Headquarters Logistics Command – Army, *Brief for CofS and DGMM HQ Log Comd on Aircraft Availability/Serviceability for One star Meeting to Discuss this Problem at 5 Avn Regt on 17 Jul 91*, Jul 1991
[22] Ibid. ' … repair parts are not readily available from RAAF stock and long lead times for overseas delivery, GSE for servicing and its components not available, maintenance hour to flying hour ratio assumed when logistics support ….was first planned has not been attained.'
[23] Ibid. 'Nine aircraft awaiting or within 50 flying hours of R3 service …. all at 5 Avn Regt …. in most cases cannibalised to maintain those helicopters still flying. …. Although designated as ILM, the complexity and scope of the R3 service make it necessary to manage it as DLM.'
[24] Ibid. '5 Avn Regt Wksps … operating two R3 service lines with two aircraft being serviced on each line …. TMS of 10 weeks with average of 2500 MMH per aircraft, …. basic service is about 1600 MMH …. Rate of Effort outstrips the capability of current support arrangements.'
[25] Ibid. 'In excess of 500 man-hours per aircraft will be required to implement all the modifications.'

- 1994 Zerate Report[26] found that:
    - The reliability of Blackhawk (sic) aircraft components is still in a fluctuating mode and further increases in operating costs can be anticipated.
    - The RAAF and RAN shared responsibility for establishing DM [Deeper Maintenance] venues is progressing slowly and is incurring unnecessary high costs in using overseas maintenance venues.
    - Blackhawk (sic) has not been subject to the MEA process since the project phase …. Indications are that the maintenance policy for the aircraft is no longer cost-effective and that a detailed analysis is overdue.
    - Support costs … of technical data - Design Authority/OEM/Configuration Management - had not been assessed.
    - The sustainment liability 'bow wave' effect … gradual reduction in stocking levels and maintenance repair … to recover day to day requirements could not be assessed, but additional funding of $12m per year should be sufficient to normalise stock levels.
    - Costs associated with rotating component life reductions, corrosion and structural cracking as well as provision for an aircraft fatigue tracking and analysis system, have not been quantified.

  confirmed that RAAF Logistics Sub-Program funds allocated for Army Aviation are inadequate to support FY 93/94 ROE, and highlighted inadequacies in RAAF/Army agreements relating to funding and human resources[27].

- 2000 Project Closure Report[28] identified the following matters that can be seen as causative to the 1991 crisis meeting and subsequent asset management challenges:
    - Arranging sustainment for a unique model helicopter, the S-70A-9 having a markedly different configuration from the standard US Army UH-60 models.
    - Poor premise for the sparing and support costs[29].
    - Immature domestic industry support-base, impacted by intellectual property to third parties and commercial disputes with Sikorsky resulting from the execution of the Australian Industry Involvement program, requiring the establishment of (unplanned) overseas Interim Repair Agreements.
    - Deferment of the acquisition's 'aircraft deficiency rectification' to the in-service management organisation.
    - Suboptimal maintenance manuals based on duplicate commercial and RAAF Supplement books.
    - S-70A-9 components retirement times not calculated using the 'more demanding' Australian usage profile.
    - Failure of the RAAF Logistics Supply Support system to become operational concurrent with the three years of Interim Support Store[30] (ISS) interim support service procured from United Technologies Corporation (UTC) Sikorsky Division.

- The aircraft was delivered 'Fitted For but Not With' some systems, a procurement approach that resulted in significant programmatic, logistics, engineering and test and evaluation effort a few year later when the in-service organisations had to fit

[26] Department of Defence, Headquarters Logistics Command – Air Force, *RAAF Support to Army Aviation*, October 1994
[27] Ibid. On a positive note, the Air Officer Commanding's final sentence was 'If given adequate guidance and resources, Army LM Sqn would be well placed to support Army Aviation; at present it cannot'.
[28] Project Air 5046 Phases 1 and 2 – *Black Hawk Utility Helicopter Project Closure Report*.
[29] Budget allocation were stressed by the prolongation of the 'interim' arrangement stated in the *Memorandum of Understanding Navy/Army/Air Force Depot Level Maintenance Support Responsibilities for Blackhawk (sic) and S-70B-2* was 'that until in-country DLM venues were established, all costs for interim repairs are borne by (the) individual Service.'
[30] Amendment 2 to the Helicopter Project *Directorate's Integrated Logistics Support Plan for the S-70A-9 Utility Helicopter* allowed for the used these stocks by Hawker de Havilland under specific conditions to continue aircraft production, with drawn stocks replenished by Sikorsky.

Electronic Warfare Self-Protection, cabin area armour and replace the obsolete GPMG M60D for the six Black Hawks deployed on OPERATION GEMINI[31].

- Black Hawk is cited in the 1998 ANAO review of Defence's conduct of life-cycle costing as an example of acquisition being over reliant on tender's data, whereby the 'actual maintenance man-hours per flying hour greatly exceeded the manufacturer's estimate; it was later found that the manufacturer's figure referred to unscheduled maintenance only[32].' This had the direct consequential effect - given the fixed military manning at the operating unit - when organic maintenance capacity was exceeded, work that was initially programmed to be conducted in-house was contracted as Deeper Maintenance, and supernumerary contacted labour was procured for the operating unit; and indirect effects of further segmenting the logistics footprint being supported with the raising of an additional maintenance venue, plus adding to the complexity of commercial and fleet management.

Activities that demonstrated intent or initial application of IAM's BoK subjects, include:

- Headquarters Logistics Command - Army initiatives[33] responding to the unexpected circumstances:
    - Army Request for Tender released in June 1991 for Black Hawk R3 servicing (to be effected by December 1991) and provision of temporary maintenance manpower at 5th Aviation Regiment Workshops (5 Avn Regt Wksp).
    - Five 'attrition aircraft' utilised; three flown at the Aviation Regiment and two as ground training devices at Army Aviation Training Centre (AAvnTC).
    - Controlling the fleet configuration by limiting modifications to the latest build standard A25-201 [final delivered aircraft] and all safety of flight.
    - Requiring a comprehensive review of [unsustainable maintenance] servicing requirements[34].

- Army and RAAF Army Aviation Joint Support Project[35], in formulation at the highest level within Defence a *Joint Recovery Plan and Supporting Process*, with planning completed by 30 November 1995 and implementation completed by December 1996[36].

- Establishment of a WSLM organisation, Army Aircraft Logistics Management Squadron (Army LM Sqn), to coordinate sustainment support, and a growing relationship with Defence Science and Technology Organisation's (DSTO) forensic engineering and Health and Usage Monitoring teams.

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[31] Six Black Hawks - A25-103, 106, 108, 202, 212 and 218 - formed the Australian Contingent Aviation Group, United Nations Transitional Authority in Cambodia (UNTAC) were deployed to Cambodia in May 1993. This was following in 1994 with OPERATION LAGOON, when five Black Hawks were sent on a short deployment to Bougainville to support the peace process.

[32] Commonwealth of Australia, Australian National Audit Office, *Life-cycle Costing in the Department of Defence*, 1998, Section 8.32.

[33] *Brief for CofS and DGMM HQ Log Comd on Aircraft Availability/Serviceability for One star Meeting to Discuss this Problem at 5 Avn Regt on 17 Jul 91*. A subsequent action, agreed in late 1994 and enacted in mid-1995, transferred Army aircraft fleet management to Army LMSqn, was reinforced the WSLM philosophy. GOC Logistics Command opening statement in his *Logistic Support Arrangements – Army Aircraft* of 6 July 1994 is; 'Current logistic support arrangements for Army Aircraft involve a number of Army and Air Force agencies. Within these arrangements no single agency is responsible or accountable for delivering the required capability related outcomes.'

[34] Ibid. ' …. ratio [MMH/FLYHR] … increased from a predicted 4:1 to an estimated 17:1'

[35] Joint Directive by the Chief of the General Staff and the Chief of the Air Staff, *Army Aviation Joint Support Project*, May 1995

[36] Forays records this as; 'and a decision was taken in mid-year to set up an Army Aviation Joint Support Project Team to study the issues and recommend a way ahead. Headed by an Army Brigadier, the team included Army and RAAF aviators, engineer and supply officers. Following several months of examination and deliberation, the team recommended the establishment of Headquarters Aviation Support Group, to be based at Oakey, and to be responsible for managing operational airworthiness for Army aviation as well as co-ordinating the logistic and engineering support of Army aircraft.'

The ADF's collective effort during the Introduction into Service phase is indicated by the PSOE[37] assessment of the twelve (asset) management questions, and the additional capstone question, is shown in Table 2.

	Question	Synopsis during Introduction into Service	P	S	O	E
1	Effective system of (asset) management?	Acquisition transition resulted in inadequate in-service logistics. Navy, Army and Air Force in-service management unable to deliver capability as planned.	X			
2	Asset properly identified and characterised?	Characterisation incomplete.	X			
3	(asset) management strategy in place for system and each system element?	Assumptions for sustaining weapon system and major components – turn times, usage, cost – flawed. Fleet well sized for attrition and flight simulator	X			x[38]
4	(asset) management responsibility assigned?	Improved during period. Enactment of the WSLM construct in late 1993 established unity of command for the major system and sub-systems. Friction existed with 'commons' and ADFLM support arrangements.	X	x		
5	Demand (requirement) defined and analysed?	Limited to Acquisition estimates.	X			
6	Understanding of Total Cost of Ownership based on sub-system cost attribution?	Limited to Acquisition estimates.				
7	Supportability analysed?	Excessive 'noise' from inherent and repeated instability in-service support system rendered elements incomprehensible.	X			
8	System condition, performance, cost and life-consumption trends tracked and analysed?	Early in life-cycle; instability in all support systems. Bottom-up zero-based budgeting initiated with adoption of WSLM in 1993 drew upon very limited known cost drivers data.	X			
9	Implementing ILS practices that prevent or reduce decay and cost?	Project ILSP created late 1987, focused on interim support in 1988 and 1989. Significant interlude to first in-service ILSP created in 1994.	X			
10	Risks identified, acted-upon and reported?	Regular reporting by Operating Units and flow of US Army and OEM data. Incorrect in-service maintenance man-hours, repairable item turnaround time and inadequate funding - all 'surprises'.	X	X	x	
11	Strategic (asset) management risks identified and reported?	Acquisition assumptions not identified as risks - maintenance man-hours, repairable item turnaround and inadequate funding - all 'surprises' – and no contingency in place when they were realised.				
12	Opportunities sought, proposed and implemented?	Activity was reactive - dominated by response to emerging constraints; insufficient spares, unscheduled nuisance cracking, and funding shortfalls.				
13	Is the (asset) management activity integrated?	Acquisition to In-service – no. Between Services at in-service – no. Within Army capability elements – no. Within logistics – yes, tentatively only after implementation of WSLM.	x			

Table 2 - PSOE Asset Management assessment for the Introduction to Service Phase

Black Hawk's introduction to service was marred by the rudimentary transition from acquisition, in a period of inter-service tension, where responsibilities between the Services and necessary Seahawk/Black Hawk interdependencies were immature. From the time the Fleet Manager at Headquarters Logistics Command – Army alerted stakeholders, it took a

[37] Present, Suitable, Operating and Effective

[38] The strategic trade-off between helicopter fleet size, Project procurement tranches (Phase 1, Phase 2A/2B, Phases 3A and 3B), and the flight simulator (Phase 3C) was effective with respect to attrition aircraft numbers. The re-sized Phase 2 activities and non-approved Phase 3 was not effective, failing to meet the ADF's need, resulting in the later Air9000 Phase 2 Additional Troop Lift

further three years for the problem to become a crisis accepted by both Army and Air Force, after which swift action was initiated. Understanding the nature of the problem was aided by the restructure within Logistics Command - Air Force, with the formation of WSLM Squadrons, and further enhanced with the transfer of Fleet Management from Army to Air Force consolidating situational awareness. Complementing the logistics restructuring, and essential for achieving the recovery, was the direction to strengthen Army's Aviation capability management.

Capability Recovery

Recovery of the capability was initiated by the 1995 *Joint Recovery Plan*, enabled by increased funding that steadily increased following an initial peak supplementation and more effective controlled with the creation of Headquarters Aviation Support Group[39] synchronising the operational flying and training activities with those of the Logistics Management Squadron. The up-tick in performance only became evident a couple of years later, as the effect of funding started to ease supply and maintenance capacity issues, and more interactive fleet management gained traction. Drawing information from Defence Annual Reports, the logistics elements of Airworthiness Board submissions, fleet management briefs and the Australian Army Aviation Association, during this decade the Black Hawk capability experienced:

- An increasing operational tempo with deployments overseas, continually testing[40] the logistics supply system:
    - OPERATION PLES DRAI[41] to Papua New Guinea and OPERATION AUS INDO JAYA[42] to Irian Jaya for drought relief.
    - Operational commitments to East Timor - International Force East Timor (INTERFET) - over 2000-2004 compounded transition of aircrew ensembles introduced for OPERATION GOLD (2000 Sydney Olympics) to running-system, and rectification of nuisance cracking[43].
    - OPERATION PAKISTAN ASSIST in response to the October 2005 earthquake in north eastern Pakistan.
    - Start of second Operational commitments to East Timor in 2006 (that continued until 2013) compounded by support to Commonwealth Games in Melbourne and tasking off Fiji.

- Repeated fleet management challenges; balancing the rectification of second (Main Transmission Beams) and third (Station 308) iterations of structural (nuisance) cracking arisings[44], with a constrained maintenance and supply base, and progressively enhancing the capability though delivery of Army Minor Capability projects[45] after

[39] Formed in early 1996

[40] The October 2005 deployment to Pakistan was a watershed moment, it was the first Black Hawk deployment (operation or exercise) that did not require bespoke sustainment arrangements – the activity was undertaken as 'business as usual'.

[41] November 1997 – April 1998 three Black Hawks and two Chinooks from 5 Avn Regt.

[42] Early 1998 – July 1988 three Black Hawks from 5 Avn Regt

[43] Defence Annual Report 2004/05; '[ROE] 85 per cent (6,378 hours achieved). The reduced level of achievement resulted from the impact of the maintenance system upgrade, a modification program to rectify aircraft cracking, and the requirement for aircrews to clear leave accumulated as a result of sustaining the five-year commitment to Timor-Leste.'

[44] Defence Annual Report 2001/02; 'The shortfall [7789 of 8540 ROE] was due to airframe cracking which has had a higher than predicted impact on aircraft availability.' November 2002 *Dot Point Brief – S-7-A-9 Black Hawk Helicopter – Impact of Structural Cracking on Availability*, '… third wave [of cracking] in April 2001' and summarises four briefings to balance unscheduled arisings, maintenance capacity, flying rate and funding. Defence Annual Report 2002/03; 'While the airframe cracking situation improved during the year, … a modification program continues for the rectification of cracking.' Defence Annual Report 2004/05; 'A modification program to rectify cracking is also affecting aircraft availability, but availability is improving …'. Defence Materiel Organisation, *AASPO A25 Brief to COMD 16 Bde (Avn)*, July 2005 describes the need to address R3 backlog, planning to fly/flying to plan for stagger management, cease unnecessary cannibalisation and better Maintenance Test Pilot optimisation at all maintenance venues.

[45] Commonwealth of Australia, Australian National Audit Office, *Performance Audit of Management of Army Minor Capital Equipment Procurement Projects*, September 2006, Section 4.35; 'The procurement of the Blackhawk (sic) Night Vision

prioritising activities[46] (but growing an engineering task backlog due to workforce constraints).

Activities that demonstrated some application of IAM's BoK subjects include:

- Progressively maturing aviation management, complementing the effects being realised in logistics with the WSLM philosophy, as:
    - Headquarters Aviation Support Group was raised in early 1996 to enact the capability recovery.
    - Commander Divisional Aviation and staff established in HQ 1st Division to provide better technical and operational control of the Regiments from 2000.
    - Aviation Capability Development Group, created in 2001 to undertake the staff effort needed introduce new capabilities to Army.
    - Formed from the Aviation Support Group and the Commander Divisional Aviation staff in 2002, the new Headquarters 16 Brigade (Aviation) was raised at Enoggera, Queensland, providing unity of command.
    - 6th Aviation Regiment (6 Avn Regt) raised at Holsworthy in 2007, discretely providing the aviation component of counter-terrorist capability[47].

- Growing, exploiting and integrating engineering, scientific and logistic knowledge[48]:
    - Ageing aircraft management model created for the Black Hawk was the result of a unique set of circumstances; a time-based regulatory requirement, the need to consider options for a mid-life upgrade, degrading sub-systems that required investment to reach mid-life, and, operational demands to improve the capability of selected avionics sub-systems. The audit went beyond the regulatory requirements for three reasons:
        - Monitoring the performance of structural (nuisance cracking) hot-spots.
        - Collecting maintenance data, aircraft usage and environmental data for major aircraft sub-systems and their components, to compare, on a reliability basis, the relative claims made for 'improved' items during any mid-life upgrade.
        - Base-lining the electromagnetic characteristics of the fleet and individual aircraft in anticipation of installation of new communication, navigation and electronic warfare equipment.
    - Predictive modelling of cost drivers utilising data gained from the ageing aircraft audit activity. The DSTO, in partnership with the Program Office, developed the Aircraft Audit Research Tool to provide a data mining and analysis capability for Black Hawk maintenance data, which was subsequently used for relating financial data to the maintenance data, providing a more detailed view of the financial consequences of operational activities and maintenance actions.
    - Education of technicians and junior officers on the management approach needed to generate Black Hawk capability. Following a 2003 study of the rate of reported 'no fault found' at component maintenance venues – a good

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Goggles Head-Up Display provides an example of a minor project effectively managed to deliver the required capability within the approved project cost and to the original schedule. … replacing the twelve aircraft that were fitted with NVG HUD in 1999 in response to an urgent operational requirement'.

[46] In the period 1996-2007 inclusive, 64 aircraft and maintenance managed item modifications were released; noticeably more than the 48 modifications released between 1989 and 1994, or the 37 modifications between 2007 and 2016 (though the Black Hawk Modification Program undertaken in the later period had the greatest benefit for the capability effecting a *de facto* mid-life refresh to meet withdrawal, and configuring the aircraft for a higher threat environment with ballistic protection, EWSP and other enhancements).

[47] But attributed as the cause for ROE under achievement in Defence Annual Report 2006/07; '[ROE] 82 per cent (6,157 flying hours). The major underachievement was due to the pause in flying when 171 Aviation Squadron relocated to Sydney.'

[48] Extracted from AIAC11 Paper WC0059, *(Ageing) Aircraft Management and Technical Leadership – Turning the Philosophy into Reality*.

indicator of on-aircraft fault finding skills – across Army aircraft found, that as a percentage of total reported failures, the rate had remained constant at around 1.5% for the last ten years; an indication that outsourcing Deeper Maintenance had not degrade this skill. Since late 2003[49], the Advanced Aircraft Technician Course has included a half-day lecture of fleet management principles, describing the Weapon System-centric view that had become core to sustainment, and technical leadership needed through-out the capability to enact them.

- Logistics lessons progressively learnt from supporting overseas operations, shaping the industry base[50], integrating useful information sets and managing the fleet, were incorporated into the in-service Integrated Logistics Support Plan[51] (ILSP) in 2000/2001 and then 2007, and procedures utilising the mature quality system (that originated with the accreditation of Army LM Sqn in 1997[52]).

- Over the period 1998 – 2007, an organic Maintenance Requirements Determination (MRD) capability for Army aviation was grown and exercised in realising meaningful maintenance policy effects for the fleets[53] managed by Amy LM Sqn. MRD adopted a 'learning by doing' approach that provided compounding improvements for the safety and availability of the Black Hawk fleet, concurrent with generating maintenance savings. A by-product was less noise in the maintenance management system, as appropriately packaged maintenance significantly reduced the disruption (crisis management) of conducting analysis intensive Maintenance Interval Extension Requests (MIER).

- DSTO longer-term research activities delivered outstanding results at critical junctures in the weapon systems growth: reverse engineering of dynamic component lifing algorithms provided an essential breathing space for engineering, logistics and programmatic to respond the 'demanding ADF usage spectrum); comprehensive data on environmental corrosively and strategy options offered in resolution of damage occurring at Townsville and in anticipation of embarked operations that saved the Army aircraft from experiencing the unscheduled structural repairs that affected the Navy Seahawk fleet; diligent data collection, modelling and analysis, in combination with improved Deeper Maintenance performance and re-learning intermediate maintenance at the Operational Unit, averted the need for an engine upgrade/replacement, conservatively saving millions of dollars, unnecessary downtime and fleet disruption; the previously mention fortuitous conduct of Life Cycle costing methodologies in parallel with the Ageing Aircraft Audit, that leveraged scientific support for a comprehensive reliability focused research tool beyond the development capabilities of the Program Office.

[49] And continued until 2012

[50] For example, in 2004 Boeing Australia successfully tested a representative aircraft's Electromagnetic Environmental Effects using a novel technique developed in Australia.

[51] Following the Project ILSP written in 1988, the first in-service ILSP was raised in 1994. Subsequent in-service ILSP updates occurred in 2013, 2014 and 2018.

[52] Darlings Downs Despatch newspaper article, *Army LM Sqn standard recognised*, reported on 15 December 1997 that the Squadron had attained a quality management system accreditation following the 1996 Air Force Logistics Command requirement for 'Logistics Management Squadrons to attain AS/ISO 9001 and Authorised Aeronautical (sic) Engineering Organisation (AEO) certifications.'

[53] AIAC16 Paper 161, *Maintenance Requirements Determination and Reliability Availability Maintainability Disciplines in support of Army Aviation – From There to Here to Where?* recounts the history of MRD and RAM from the formation of Army LM Sqn until 2014. The presentation associated with the Paper focused on the materiel effects; creation of practicable periods between scheduled maintenance, tangible and opportunity cost savings, and reduced maintenance burden.

The PSOE assessment of the Capability Recovery phase is given in Table 3.

	Question	Synopsis during Capability Recovery	P	S	O	E
1	Effective system of (asset) management?	Aviation command and control effected. Quality management system enacted. Navy-Air Force WSLM coordination matured. Minor project synchronisation improved.	X	X	x	
2	Asset properly identified and characterised?	ADFLM and commons items teams better defined 'asset' boundary. Aircraft sub-systems still 'surprising'. Integrated aircraft and support system to multiple Navy ships.	X	X		
3	(asset) management strategy in place for system and each system element?	Inventory management and MRD matured. Data gathered and purified to populate bespoke models. Performance monitored. Data driven, reliability-based, decision making.	X	X	x	x
4	(asset) management responsibility assigned?	WSLM construct bedded in. Capability management interaction maturing.	X	X	x	x
5	Demand (requirement) defined and analysed?	Use of predictive models – PATTRIC, AIMS – but challenged to work with repairables.	X	X	X	
6	Understanding of Total Cost of Ownership based on sub-system cost attribution?	Purifying data to feed DSTO model, decision to have organic cost modelling capability. Modelling informed fleet strategic decisions.	X	x	x	x
7	Supportability analysed?	Fleet management cause and effect relationships understood, budgeted and enacted.	X	X	X	
8	System condition, performance, cost and life-consumption trends tracked and analysed?	Number of corporate and in-house performance measurement systems meeting decision-maker RFIs. Data and analysis lagging by up to 2 months.	X	X	X	
9	Implementing ILS practices that prevent or reduce decay and cost?	In-service ILSP periodically updated. Improved industry support-base. Insights from Ageing Aircraft Audit reduced conservatism.	X	X	X	x
10	Risks identified, acted-upon and reported?	Defect reporting management able to draw on purified failure data for better maintenance/reliability response.	X	X	x	
11	Strategic (asset) management risks identified and reported?	Monthly report internal to DMO/CASG. Twice yearly reporting to Chief of Army.	X	X	X	x
12	Opportunities sought, proposed and implemented?	Limited by discretionary resources and commercial opportunity. Regularly updated comprehensive procedures synchronised across capability.	X	X	X	
13	Is the (asset) management activity integrated?	New minor capability Acquisition to In-service – yes. Between Services – improved. Within Army capability elements – yes. Between WSLMs/SPOs – improved	X	X	X	x

Table 3 - PSOE Asset Management assessment for the Capability Recovery Phase

It took twelve years – the capability recovery period – to understand the complexity of the environment and thence establish the management systems, resourcing and responsive support-base necessary for Black Hawk to start tracking on the planned ROE trajectory. The capability recovery period coincided with multiple overseas operations - with the benefit of repeatedly stress-testing the systems driving improvement and a more robust capability – and maturing capability management. Prioritisation within the ADF and the industry support-base was a regularly practiced art. Professionalisation within operations and sustaining logistics teams – seeking better ways of working and working together – and generating credibility and trust based on proven planning, performance and advice, are distinct features of this period, that then continue to be fostered to effect the most recent period of capability delivery.

Capability Delivery

In FY 08/09, the Black Hawk fleet achieved the planned ROE, and start of an extended period of delivering the required capability (based on planned ROE as the benchmark); the management system built up over the previous decade proved sufficiently resilient to recover from sequential years (FY 09/10 and 10/11) of over-flys, mounting the argument and winning resources in time to be effective, harvesting inventory and facilitating industry to stabilise events that historically would have curtailed the capability for the next five to seven years.

Materiel sustainment activities during this period were generally favourable, but with some decay of previously core capabilities, such as:

- Completing a suite of logistics modifications thereby creating three stable sub-fleet configurations, reflected greater industry capacity and responsiveness[54], and better project management consistently delivering Army and Air Force minor projects.

- Achieving more responsive and predictable Deeper Maintenance by integrating accurate labour data, detailed task analysis and a 'notch effect' performance methodology, market tested and contract transitioned without loss of output. The Operational Maintenance labour supplementation/fly-in fly-out contract had adopted a similar performance approach, and enabled for the first time, Australian contractors to work in an area of operations, providing a Forward Repair Team for on-going operations in East Timor between scheduled military maintenance team rotations.

- Consolidation at Sydney; with Black Hawk training support operations at the School of Army Aviation[55] in Oakey, Queensland, ceasing in December 2013, and the drawdown of Black Hawks from the 5 Avn Regt in Townsville, Queensland, commenced[56], operations from 6 Avn Regt will continue until the cease operations date, allowing for efficient support being generated from the Sydney-Nowra region.

- Consolidation of (a surge venue) Deeper Maintenance at Archerfield, followed by closure of the long-standing Townsville capability, and repackaging of the R3 servicing into smaller blocks (R31, R32, R33 and R34) that can be effectively conducted concurrently with the R2 servicing, has realised the original Project premise of being able to conduct all on-aircraft maintenance at the Operating unit. Residual Seahawk deeper maintenance capacity, and an embedded contractor workforce, is utilised to relieve the Black Hawk maintenance liability at 6 Avn Regt aiding transition to the MRH90 Taipan.

- Consistent attrition of the organic MRD capability, at a rate pre-empting the withdrawal of the Kiowa and Black Hawk fleets, creating vulnerability for future support.

- Difficulties in retaining specialist management knowledge within Defence and the industry support-base – engineering, minor projects, logistics, commercial – compounded by the reduction in staffing matched to the reduction in fleet and tempo, and individual transfers to newer enduring weapon systems, operated under a different logistics support concept, for career security.

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[54] Department of Defence, Defence Materiel Organisation, *Engineering Award Black Hawk Helicopter Modification Program (BHMP)* Helicopter Systems Division, August 2011, cites; the [Project] Team successfully integrated a set of complex modifications to the Black Hawk Helicopter to enhance self-protection, improve reliability and mitigate system obsolescence. Additional modification lines were established to double production and address delays.'

[55] Crash Response Helicopter tasking continued until June 2018.

[56] Defence Report FY 13/14.

Consolidation of the previous decade's efforts, and the better initiates undertaken more recently, have resulted in the gradual reduction in engineering and logistics activities, as shown in Figures 8, 9 and 10, the clearing of backlogs and, to a degree, minimising the impact of natural staff attrition with an ageing workforce.

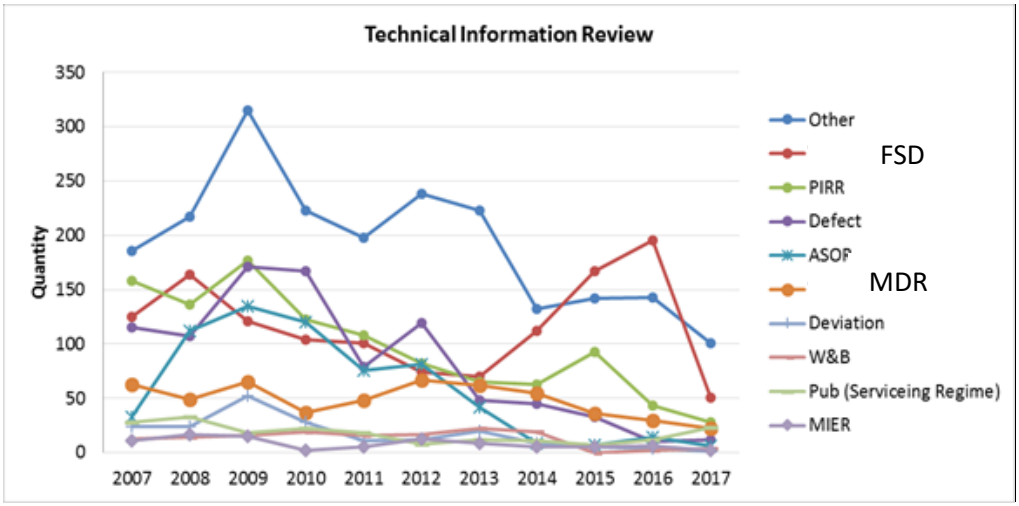

Figure 8 – Change in Technical Information Review 2007 - 2017

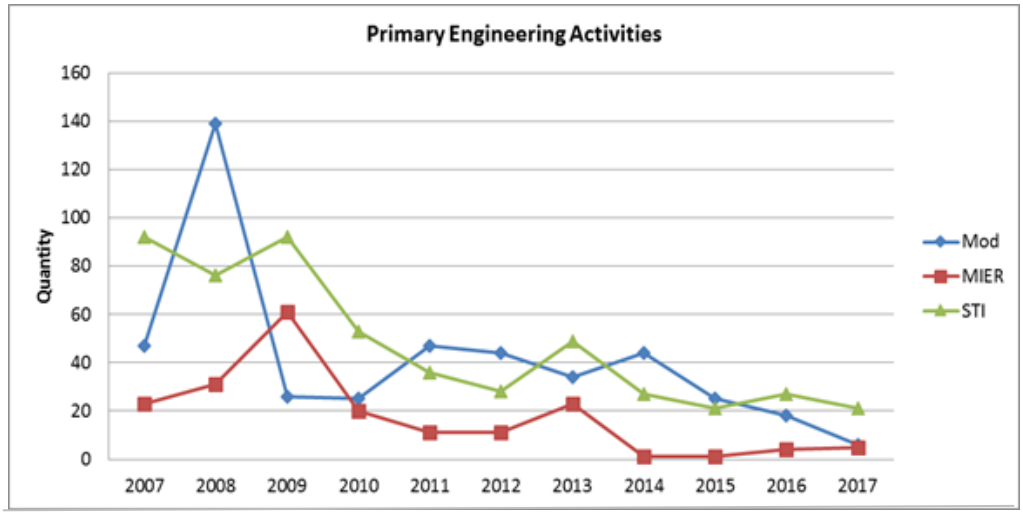

Figure 9 – Change in Modifications, MIERs and Special Technical Instructions 2007 -2017

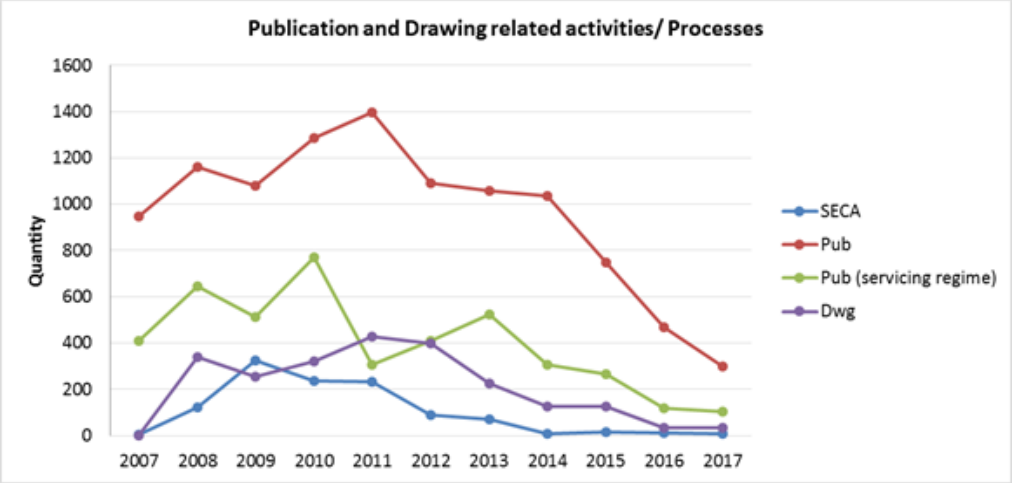

Figure 10 – Change in Supplementary Engineering Changes, Publications and Drawings activities 2007 - 2017

Black Hawk capability delivery phase built upon the IAM's BoK skills, techniques and practices already identified in Table 3, and, as seen in Table 4, progressed many of the attributes for better synergistic results:

- Strategic[57] Life of Type investment commensurate with planned operating life, recalculated a number of times, and proven robust, matched with logistics constraints for achieving fleet withdrawal and robust forecasting the risk profile[58].

- Repeated improved value for money contracting activities, synchronised across a series of different commodities, resulting in cogent overall improvements to the support system, responding effectively to surge, and now efficiently during fleet drawdown.

	Question	**Synopsis during Capability Delivery**	**P**	**S**	**O**	**E**
1	Effective system of (asset) management?	Aviation command and control matured; surges managed. Integrated Aviation safety review and management conducted. Capability expansion and then contraction managed. Minor capability projects effectively integrated.	X	X	X	X
2	Asset properly identified and characterised?	Whilst an ageing aircraft, relatively few 'surprises'.	X	X	X	x
3	(asset) management strategy in place for system and each system element?	Efficient policy in place but gradual loss of MRD capability risks opportunity to make bold adjustments.	x	X	X	x
4	(asset) management responsibility assigned?	WSLM construct remains robust. Effective transition of Regulatory frameworks.	X	X	X	X
5	Demand (requirement) defined and analysed?	High organic proficiency and knowledge of cost drivers, industry performance and logistics effect.	X	X	X	X
6	Understanding of Total Cost of Ownership based on sub-system cost attribution?	Effective systems developed, but loss of effective costing modelling capability during 2010-2015/16, partially restored. Knowledge retained by key individuals (not systemic).	x		x	x
7	Supportability analysed?	Fleet management cause and effect relationships understood, budgeted and enacted with accuracy.	X	X	X	X
8	System condition, performance, cost and life-consumption trends tracked and analysed?	In-house performance measurement systems meeting decision-maker RFIs.	X	X	X	x
9	Implementing ILS practices that prevent or reduce decay and cost?	In-service ILSP current and refocused for withdrawal and disposal.	X	X	X	X
10	Risks identified, acted-upon and reported?	Defect reporting improved with greater use of digital pictures and electronic forms.	X	X	x	
11	Strategic (asset) management risks identified and reported?	MSA/PMP effective. Prompt crisis resolution.	X	X	X	X
12	Opportunities sought, proposed and implemented?	Better aviation planning has allowed for both realistic contingency planning and concurrent cost minimisation.	X	X	X	X
13	Is the (asset) management activity integrated?	Aided by system simplification as all operations conducted from a single airfield. Cessation of S-70B-2 Seahawk operations negated common item management arrangements.	X	X	X	X

Table 4 - PSOE Asset Management assessment for the Capability Delivery Phase

[57] Defence Report FY 09/10; 'The increase [$101m actual compared to $73m budget] in Black Hawk costs was driven mostly by purchase of some spares to reach the life of type for Black Hawk, which is being replaced by MRH-90.'

[58] 2016 *Black Hawk System Equipment Obsolescence and Availability Risk Assessment* analysed the 2016 status quo, expected 2018 and 2022 environment, received an industry peer review twelve months later and was considered accurate. The work remains valid and enacted logistics strategies have not been disrupted.

The last decade of Black Hawk operations has benefited from the actions taken in the twelve years after the 1995 Army and RAAF Army Aviation Joint Support Project initiated recovery, and surpassed the work undertaken in that period with the fleet now stabilized in three distinct configurations, and management tailored to each sub-fleet. A long period of stable management structures[59] and relationship building has been incorporated into practices, agreements and contracts, within the ADF and into the supporting industry base. Some vulnerabilities are becoming evident, but offset to a degree by system simplification and latent value and depth that still exists in the resource base.

Conclusion

The Black Hawk capability has provided Defence, and Army Aviation in particular, an asset management learning opportunity. The capability problems that materialised early in life cycle demonstrated the paucity of integration across Defence's management practice leading up to the crisis that was seen in 1991 and eventuated 1995. The learning curve, real on-the-job training given the tempo of operational deployments, was a result primarily of maturing command and control arrangements matched with increasing teams 'asset management' professionalism; you could visualise this as the slow growth of very few 'heat bubbles'(circa 1995) on the Asset Management BoK heat map in Figure 2, as the thirteen questions of Tables 2, 3 and 4 translate from 'present' to 'suitable' to 'operating' and finally 'effective' over the next twelve years. Following this analogy, the current phase of Black Hawk consistently delivering capability, is more of the heat map being a burner atop a gas stove, with the jets on the burner alight, flickering in response transient disruption, but still cooking. This outcome is the result of better integrated information and analysis informing decision making for both considered short term asset value generation but also long term asset value preservation.

[59] From the Black Hawk aircraft's perspective, Army Aviation command and control has been very stable since the creation of 6 Avn Regt, with the only meaningful subsequent change occurring in 2011, following direction in late 2010.

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