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Seasprite – what went wrong?

INTRO: The problems with the Super Seasprite program were designed into the project from the outset. By the time they had become obvious Defence had reached the classic point of no return: it would have cost more to cancel the project and acquire a new aircraft than to proceed with it. But the history of the project shows that Defence was anything but a 'smart buyer'.

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18,500wds

The Super Seasprite debacle had its genesis in four decisions made by the Australian Federal Government and the Department of Defence during the mid-1990s. The first was to pursue a joint program with Malaysia to design and build a new class of Offshore Patrol Combatants (OPC). The second was to procure a helicopter which would be embarked upon both the OPC and the Royal Australian Navy's new Anzac-class frigates.

The third decision was that this helicopter should be equipped with a highly capable anti-ship missile whose stand-off range would protect the helicopter from the target ship's own defences. Finally, it was decided that the helicopter should have an all-new avionics and sensor suite to enable it to be flown by a two-man crew rather than the three-man crew which is normal aboard naval helicopters.

These decisions, and their compounding effect on each other, effectively doomed the project to an ignominious death. Many of them seem to have been made without the rigour one would have expected, and therefore many of the problems which killed the project weren't identified at the time and so didn't emerge publicly until it was too late to do much about them.

That said, the minister for defence, The Hon. Joel Fitzgibbon MP, has not stated a specific reason for cancelling the project in March 2008. The two principals in this story, the Commonwealth of Australia and Kaman Aerospace International Corporation, have agreed to remain silent on the details of their contract termination agreement, so it's likely many of the facts will never become publicly known.

However, there appears to be no 'smoking gun' in the sense that a single decision or a pattern of incompetence by a specific individual or organisation can be held solely to blame for the project outcome.

Just as success has many fathers, so a major disaster is generally the result of several separate but compounding errors or omission and commission – many of which were made by honest, intelligent people trying to do their work to the best of their abilities.

Much of the information gathered for this article was provided by some of these people and other primary sources, generally on a non-attributable basis. For that reason the only people named in the article are those whose remarks are recorded in Hansard or quoted in media releases or media interviews.

Genesis

Project Sea 1411 had its roots in the RAN's original intention to acquire helicopters for its Anzac-class frigates. These were due to enter service in 1996, but no embarked aviation capability had been specified at the time they were ordered in the late-1980s, though its organic aviation capabilities – flight deck, hangar size and so on – were based loosely upon the Seahawk.

In the very early 1990s the RAN was still taking delivery of Sikorsky S-70B2 Seahawks to equip its six Adelaide-class FFG frigates. These were ordered in two batches of eight aircraft each under Phases 1 and 2 of Project Sea 1308; a projected Phase 3 – Destroyer Utility Helicopter - would see the purchase of additional Seahawks for the fleet. The functional needs analysis for Anzac ship helicopters conducted at that time by the Defence Science & Technology Organisation (DSTO) supported the idea of buying still more Seahawks for the Anzac frigates under Project Sea 1411.

The S-70B2 was a heavily modified variant of the SH-60F Seahawk helicopter already in service with the US Navy, but featured a unique mission system designed by Rockwell Collins for the RAN's quite different cockpit and crewing philosophy. The RAN also examined the SH-60B LAMPS (Light Airborne Multi-Purpose System) II variant and rejected it because this was considered not to have the operating autonomy required by the RAN; this view ignores the cycle of capability upgrades introduced by the US Navy over the years which the RAN could also have implemented if it had selected a similar mission system.

Australia's S-70B2 was expensive, thanks to the new mission system; this also took much longer than expected to be integrated, and naval aviators have expressed their surprise that this experience wasn't taken into account later on when considering the functional requirements for Project Sea 1411. Eight S-70B2s were manufactured by Sikorsky at Hartford, Connecticut, while the remainder were assembled by AeroSpace Technologies of Australia (ASTA) at Avalon, VIC; the last of these was delivered in 1992.

Even though the S-70B2 is a unique model, buying more Seahawks under Sea 1411 would have made considerable sense: a diverse fleet of different types of aircraft results in a significant logistics, training and operational 'overhead'. It's been estimated that of the $675 million Australia paid for the S-70B2, between 60 and 70 per cent was accounted for by infrastructure and non-recurring expenditure on engineering and training facilities. Acquiring more Seahawks to embark on the Anzacs, even if these didn't share all the features of the S-70B2 mission system, would mean many of these facilities and non-recurring costs could be amortised across a larger fleet.

Not only would these aircraft have had considerable logistics commonality with the S-70B2, the Seahawk was already integrated with the Penguin anti-ship missile as well as the active and passive sensor suite required for surveillance and missile targeting.

Furthermore, it has been the experience of most navies which operate small flights of one or two helicopters embarked on frigates and destroyers that the logistics required to maintain this effort have a relentless arithmetic of their own: for every helicopter embarked on a ship another 1.6 or 1.7 helicopters is required ashore. So to maintain 10 aircraft at sea needs a total force of 26 or 27 helicopters. Acquiring another 10 or 12 Seahawks under Sea 1411 would have been an efficient and economical way of ensuring that at least four of the FFGs and six of the Anzac frigates would always have a helicopter embarked.

These good intentions were corrupted by the emergence of the Offshore Patrol Combatant (OPC) project from the 1991 Force Structure Review. The OPC was conceived as a replacement for the RAN's 15 Fremantle-class patrol boats and wasn't originally intended to embark helicopters. But it was realised at an early stage that their surveillance capabilities would be enhanced significantly if they were equipped with a helicopter. The original plan to acquire 15 OPCs was reduced to nine ships, with the money saved going towards the cost of a new helicopter for them.

The RAN examined the cost/benefits of acquiring the same helicopter for both the Anzac frigates and the OPC and concluded this could be done; if the RAN was to carry the additional overheads associated with a new type of helicopter, this was a means of ensuring the same pool of helicopters could be embarked upon two different classes of ship, rather than having a small and possibly unsustainable fleet of helicopters dedicated solely to OPC operations.

As described in the 1999 Australian National Audit Office report on the Naval Aviation Force, these helicopters were required to extend the ships' surveillance and strike range by providing them with an enhanced ability to detect, intercept, track, classify, identify and engage surface contacts. They were to be fitted with sensors and communications equipment and weapons to enable them to operate beyond the parent ship's visual and electronic horizon with a secure data link for tactical information.

The helicopters would be equipped with a surface search and targeting radar, Forward-Looking Infra Red (FLIR) sensor and Electronic Support Measures (ESM) system for passive surveillance and intelligence-gathering, along with an anti-ship missile.

The helicopter/missile combination would allow the ship to engage targets from well outside the range of the target's own weapons. The helicopter would also carry Mk46 lightweight torpedoes to attack submarines detected by the frigate's own sonar, or by other ships or maritime patrol aircraft; however, it was never required to carry a sonar of its own, nor to drop sonobuoys for anti-submarine duties.

The OPC program gained extra political momentum when it was realised the Royal Malaysian Navy (RMN) also needed a similar class of Offshore Patrol Vessels (OPV) of a similar size and configuration, and at around the same time. This was a time when the Federal government was actively pursuing closer ties with Australia's regional neighbours and the potential for a collaborative program was obvious and attractive at the strategic and political levels.

Notwithstanding the imprimatur of the Force Structure Review there was an ambivalent attitude within the ADF and the RAN towards the OPC concept: the ship was too big and expensive to be a cost-effective patrol boat and too small and lightly armed to be a credible surface combatant. It is the politics of the day rather than any hard-headed analysis of Australia's capability needs which appear to have driven the project at this time.

Melbourne-based Transfield Shipbuilding (now part of BAE Systems Australia), which was prime contractor for the Anzac frigate, decided to pursue both the OPC and OPV projects with a similar design. The possibility of a joint Australia-Malaysia program was raised in April 1992 when Malaysia's then-defence minister, Najib bin Tun Razak , visited Transfield in company with Australia's then-defence minister Senator Robert Ray.

The RMN's requirement was for up to 27 OPVs with an estimated value of up to $3 billion, while the RAN planned initially on the basis of a 9-ship buy (with options for three more), along with helicopters, at a combined price of $2 billion.

Defence undertook to work with the RMN on development of a specification for the OPCs but, concerned at the potential implications for a competitive tender in its own acquisition program, it made no commitment to buy the RAN's OPCs from Transfield. The Cabinet agreed to provide $12 million for Transfield to carry out initial OPC design studies, but on condition that the Transfield design was used as the basis for an open tender to build the ships for the RAN. Interestingly, artist's impressions from this period of Transfield's outline OPC design show it with a Lynx helicopter embarked.

At this time Malaysia was being courted by warship builders from around the world, so competition for the RMN contract was expected to be tight. Transfield's advantage in this battle stemmed from the fact that only Australia was proposing to build a similar class of ship at the same time and therefore could share project risk and parent navy responsibility.

While the Anzac frigates could accommodate the Seahawk, the RAN's requirements for Project Sea 1411 – Intermediate Naval Helicopter (as it was then officially described) were driven by the OPC program. At 81.5m in length and 1,350 tonnes displacement the OPC was considered too light, with too small a flight deck and hangar, to accommodate a variant of the 10-tonne Seahawk. A lighter helicopter in the 5-6 tonne class was required, and as no helicopters had been procured as yet for the RAN's new Anzac-class frigates it was decided these should embark the same helicopter as the OPC.

It is clear that, if the OPV/OPC Program had never existed, the RAN would almost certainly have acquired more Seahawks to equip its Anzac frigates; it's extremely unlikely the Department of Defence's Force Structure Policy & Programming Committee (FSPPC) would have allowed the RAN to acquire anything else without a compelling operational reason to do so. This is despite a less than cordial relationship between the RAN and Sikorsky at this time following the difficulties encountered developing a small number of Seahawks to a unique and complex avionics configuration and then bringing them into service.

At this stage Australia's requirement for a two-man crew, instead of the three-man crews commonly used by naval helicopters, began to emerge.

It was considered that eliminating a crew member and crew station would reduce weight, free more space for internal equipment and so increase the aircraft's payload and range/endurance. Also, even as far back as the early-1990s the RAN was experiencing some difficulties recruiting and retaining aircrew so the prospect of a two-man crew was attractive for many reasons.

The early contenders were the Royal Navy's Westland Super Lynx, the US Navy's Kaman SH-2G Super Seasprite, the Eurocopter AS365 Dauphin/Panther operated by the US Coastguard and French Navy, and a marinised variant of the Sikorsky S-76.

The Royal New Zealand Navy, which was introducing its two Anzac-class frigates in parallel with the RAN, also sought a new helicopter to replace its ageing Westland Wasps and monitored the RAN's program closely but without committing to acquire the same aircraft.

Naïve expectations

With hindsight, hopes for a joint Australia-Malaysia patrol boat program were naïve. In November 1993 Malaysia's prime minister, Dr Mahathir Mohammed, who was notoriously ambivalent (at best) towards Australia, took offence to comments by Australia's prime minister, Paul Keating, at that month's inaugural APEC Summit in Seattle. Keating rebuked the Malaysian prime minister for failing to attend the summit, describing him as 'recalcitrant'. The resulting diplomatic and political row simmered for years and it is hard now to imagine how anybody thought Transfield stood a realistic chance of winning Malaysia's OPV contract.

Meanwhile, the RAN and Defence A&L went ahead with Project Sea 1411, working on the assumption the helicopter would be embarked upon the RAN's eight Anzac-class frigates and at least six OPCs.

The contest for Sea 1411 was looking like a three-horse race: Lynx versus Dauphin versus SH-2G. However, following the announcement in 1995 that France would carry out nuclear tests at Mururoa Atoll in the Pacific in January 1996, Eurocopter dropped out of the contest leaving Westland and Kaman to slug it out.

At the start of the program the RAN project team told all the competitors (and themselves) that they would not repeat the mistakes made on the RAN's S-70B2 Seahawk program: this was considered to have suffered from specification creep and poor program formulation. This advice fails to acknowledge the fundamental, and expensive, error it made on the Seahawk project and then repeated on the Super Seasprite project: specifying an all-new and unique mission system for a small fleet of aircraft, with all the cost, schedule and technical risks that entailed.

A key requirement for the RAN was an anti-ship missile capability to extend the effective surface strike range of the Anzac frigates; the Navy wanted a missile with real punch, something that could disable or sink an enemy ship. It selected Norwegian company Kongsberg's Penguin Mk2 missile, which was already in service aboard US Navy Seahawk helicopters. The sea-skimming Penguin Mk2 weighs 385kg and is 3m long; its warhead alone weighs 125kg, around 75 per cent of the massive warhead in the Exocet anti-ship missile. It uses inertial navigation and passive infra red guidance and has a range of more than 34km at a high sub-sonic speed.

The missile requirement also drove requirements for the helicopter's very capable sensor suite. As well as using the radar for target identification and targeting the RAN wanted, if necessary, to be able to do this passively, using the aircraft's infra red sensor and Electronic Support Measures (ESM) system to detect, locate and then engage the target without betraying its own position by using its radar. Whether modern Rules of Engagement would allow this sort of tactic in any scenario short of all-out war is a moot point, especially as the missile lacks a manual termination capability once launched; at the time, however, the requirement made operational sense.

The Westland Super Lynx offered to the RAN was usually armed with the combat-proven British Aerospace (now MBDA) Sea Skua anti-ship missile. The semi-active radar-guided Sea Skua weighs 145kg all-up, with a 28kg warhead, is 2.5m long and has a range of about 25km at a speed of about Mach 0.8. But this isn't the missile the RAN wanted. To increase its payload Westland replaced the Super Lynx's existing Rolls-Royce Gem turboshafts with more powerful LHTEC CTS800 engines (which are now the baseline for the Future Lynx family). But although it could now carry two Penguins, the aircraft lacked the range and endurance required for the mission.

While the Super Lynx could be operated with a two-man crew its federated avionics and sensor suite lacked the levels of integration demanded by the RAN. To meet the requirements of Project Sea 1411 Westland developed a new glass cockpit and avionics architecture based on that of the Anglo-Italian EH101 helicopter. As well as having a proven avionics core the company also had a track record of carrying out large, complex avionics integration programs – at the same time as it tendered for Sea 1411, for example, it was also bidding for the British Army's AH-64W Apache and the RAF's Merlin Mk3 helicopter programs.

The SH-2G Super Seasprite had greater power (from two General Electric T700 engines, similar to those powering the RAN's existing Seahawks) and payload so could carry two Penguins; though knowledgeable engineers and aircrew have told the authors that on hot days when the air density was low it would struggle to get airborne at the SH-2G(A)'s Maximum All-Up Weight of 14,200lb carrying sufficient fuel to loiter for the required length of time at the range demanded by the RAN.

The RNZN was also attracted to the Super Seasprite, especially as the SH-2G model had largely the same sensor fit as the US Navy's SH-60 Seahawks. However, Kaman felt they faced an uphill battle in New Zealand because they believed the specifications for the RNZN's shipboard helicopter were basically written around the Sea Lynx.

Meanwhile, the RAN had formalised its requirement for a two-crew aircraft, combining the previously separate roles of the Tactical Coordinator (TACCO) and Sensor Operator (SENSO). Most maritime helicopters operating in the Anti-Submarine Warfare (ASW) or Anti-Surface ship Warfare (ASuW) roles have a three or four-man crew; the pilot and TACCO are normally both pilots who take it in turns to fly the aircraft – one performs the TACCO role while the other concentrates solely on flying the helicopter. Helicopters such as the RAN's Sea Kings are flown by two pilots with an Observer acting as TACCO in the main cabin and an aircrewman SENSO alongside him.

The concept for the RAN's Seahawks was to have a single pilot with an Observer in the co-pilot's seat acting as TACCO and a SENSO located at the console in the main cabin. In order to combine the TACCO and SENSO roles without an unacceptable increase in workload, whichever helicopter was selected for Sea 1411 would require an all-new mission system, including a new avionics architecture and Human-Machine Interface (HMI). And the pilot would be required to carry much more of the sensor management and tactical planning workload than before; this, as we shall see, had significant repercussions for the Super Seasprite.

Cockpit workload issues aside, while the RAN's logic in seeking a two-man crew may have been sound in theory, it's clear that the people within the Directorate General of Force Development (part of HQ ADF) responsible for framing the requirement simply didn't understand the costs, technical challenges and level of technical and physical risk they were exposing themselves to. And according to Australian T&E veterans, the concept is not known to have been the subject of investigation, analysis or trial.

The DMO issued its Request for Tenders (RFT) in October 1995 and in March 1996 bids were submitted by Westland and Kaman for 14 aircraft, with options to bring the total up to 23 or 30 in all. However, it became clear that acquiring 14 aircraft of either type would push the project costs well above the approved project budget; the tender evaluation process saw a significant amount of number-crunching.

Kaman scoops the pool

On 17 January 1997, a month before tenders for Malaysia's OPV contract were due, Australia's then-minister for defence, Ian McLachlan, announced the RAN would acquire 11 SH-2G(A) Super Seasprites to equip its eight Anzac-class frigates. "Further orders of the helicopter will be considered to take account of possible future needs and to support the prospective Offshore Patrol Combatant," McLachlan said.

Barely two months later the RNZN also selected the Super Seasprite. Defence minister Paul East said in a statement at the time the Super Seasprite and Super Lynx were evaluated for performance, airworthiness, industrial benefits, risk management and cost. The RNZN ordered four aircraft, at a cost of NZ$274 million, then exercised its option to acquire a fifth; these aircraft were due to enter service in 2000. New Zealand's helicopters were to be equipped with the baseline SH-2G radar and forward-looking infra red (FLIR) sensor for surveillance, with ESM for passive surveillance and self-protection and AGM-65 maverick missiles for anti-surface vessel operations.

As far as the RAN was concerned, the SH-2G offered superior performance at a price about 10 per cent below the Lynx, with a superior in-service support package. Furthermore, the Super Seasprite was considered to be a lower risk solution because it didn't require a complete change of engines and gearbox on top of the avionics architecture changes that were required.

Kaman offered the RAN “re-manufactured” Super Seasprites – SH-2F airframes held in storage at the Davis-Monthan “boneyard” in Arizona. These would be refurbished and fitted with a new upper fuselage section to restore them to as-new condition with a 10,000 hour service life certified by the US Navy. This was estimated to have saved over $25 million (and resulted in the RAN getting at least one more aircraft for its money than it would otherwise have been able to afford) but was a controversial decision at the time.

The authors have been told of concerns raised by members of another high level Defence committee, the Defence Source Definition Committee (DSDC) that selecting refurbished airframes might substitute an upstream saving for a downstream cost; it seems a proper Life Cycle Cost analysis wasn’t undertaken.

Lest it be thought Defence went through this process blindly, it must be recorded that the department’s key Force Structure Policy & Programming Committee (FSPPC), which was chaired by the Deputy Secretary Strategy & Intelligence and included the Vice Chief of the Defence Force, Assistant Chief of the Defence Force (Development) and First Assistant Secretary Force Development and Analysis, examined the project carefully on a number of occasions.

The authors have been told that in 1995 the committee was furnished with advice from DSTO that Kaman’s choice of US company Litton as sub-contractor responsible for development of the new avionic system carried some significant risks: not only did DSTO consider Litton’s track record to be less than stellar, its relationship with Kaman was poor as well. And Defence A&L’s eagerness to save money by having Kaman ‘re-life’ elderly airframes which had been in storage in the Arizona desert was seen as especially risky, given these aircraft had already spent their service lives at sea in the hands of the US Navy and would be required to spend a second life at sea under the Australian white ensign.

Defence A&L was advised in writing by one official who was party to these deliberations that the re-manufacture of Super Seasprite airframes deserved a ‘gold star award’ as ‘the worst decision ever made by Defence Acquisition.’

While the structural integrity of these re-manufactured airframes turned out not to be an issue, public and media perceptions that Australia had bought 40-year-old cast-offs did the project untold damage in the years to come. New Zealand avoided this by ordering new-build airframes.

Kaman hadn’t actually built a new SH-2 airframe since 1987: the last batch of these helicopters was ordered as SH-2Fs, with General Electric T58 engines, but some were completed as SH-2Gs with the vastly more powerful T-700s (but largely the same gearbox, and therefore some performance limitations); and several SH-2Fs were upgraded to SH-2Gs for the US Navy. The last SH-2F retired from US Navy service in 1993, while the SH-2G remained operational with the US Navy Reserve until 2001.

The design of the SH-2G avionics and flight control system meant it was a single pilot IFR (Instrument Flight Rules)-rated aircraft; this allowed the co-pilot to “fight” the aircraft as mission commander, with the pilot simply flying the directed flight profiles to place the aircraft and its sensors in the correct spot. In US and New Zealand service the SH-2G was typically operated by a three-man crew: pilot, co-pilot and so-called AW – an aircrewman sensor operator and ASW specialist.

By contrast, Australia's 11 aircraft were to be equipped with an all-new Integrated Tactical Avionics System (ITAS) developed by Litton Guidance & Controls in Northridge, California. Litton was selected because of its wide experience working on airborne mission systems for the SH-2F, the SH-60 family and the P-3C Orion. US sources close to the ITAS program told the authors the RAN also liked the idea of using Litton because it was bidding for (and eventually won) the US Marine Corps' AH-1 Cobra upgrade program and this was seen as an important developmental synergy.

Interestingly enough, the two other airborne mission systems giants, Rockwell Collins and IBM Federal Systems didn't want to offer compliant systems, the source said: Rockwell Collins wanted only to integrate the communications while IBM Federal Systems wanted to offer a solution which eventually evolved into the US Navy's current common cockpit solution. IBM Federal Systems is now Lockheed Martin Integrated Systems, located in Owego, New York – and it is the prime contractor for the MH-60R Seahawk which is a contender to replace both the S-70B2 and the Super Seasprite in RAN service.

The highly automated ITAS, with four colour multifunctional displays replacing the existing aircraft's conventional analogue instrumentation, was designed to reduce cockpit workload and provide the full TACCO and SENSO functionality required for two-man operations across the full spectrum of missions. Put simply, the RAN wanted the sensors fully fused and the aircraft to fly itself. This was an ambitious goal in 1995, and a very significant technical challenge for an aircraft whose design dates back to the 1950s.

Furthermore, Kaman had never previously had responsibility for managing the development of an entire new digital avionics suite for one of its aircraft: the development of the SH-2G was managed principally by the US Navy. Notwithstanding that Litton was an acknowledged leader at that time in maritime airborne systems integration, Kaman was the prime contractor responsible for ensuring everything went well and lacked experience handling a major sub-contractor on such a project.

The RAN selected the proven Telephonics AN/APS-143 inverse synthetic aperture radar (ISAR), but delayed a choice of FLIR and ESM systems until the DMO had completed evaluation of tenders to provide similar equipment for the RAN's Seahawks as part of their planned upgrade program. The aim was to acquire a common set of equipment for both helicopter types.

Kaman and the DMO signed the $661.8 million prime contract in June 1997, with deliveries scheduled for 2001. In September 1997 the DMO selected the Raytheon AN/AAQ-27 FLIR; it also selected the Israeli Elisra AES-210 ESM system.

The SH-2G(A) mission equipment package ran on a Mil-Std1553B data bus. It included the ITAS, the APS-143 radar, AAQ-27 FLIR, AES-210 ESM, the high capacity Link 11 Tactical Data Link (TDL), a precision navigation system, and multiband radios. The sensor fit and Penguin missiles resulted in weight growth: Maximum All-Up Weight (MAUW) rose from the SH-2G's 13,500lb to 14,200lb on the SH-2G(A); this was accommodated in part through the adoption of new, high-technology carbon fibre main rotor blades.

According to US industry sources close to the Super Seasprite program the challenges of the ITAS software development and integration program were well understood by the Sea 1411 project office at the time – indeed, one senior member of the project team warned Litton at the outset that the company was proposing too aggressive a schedule; and in recognition of this the RAN stationed a full-time project representative at Litton's facility in California to monitor the program.

The ITAS was a very ambitious development project. It was designed to coordinate and format the onboard and offboard sensor data to present the crew only with usable information. It was also intended to automate TDL operations and other complex tasks to reduce crew workload. The Georgia Institute of Technology was contracted to provide human engineering and cockpit design expertise to develop the Human-Machine Interface (HMI) for ITAS.

In a departure from previous maritime helicopter practice, Electronic Flight Information System (EFIS) symbology, tactical data, and sensor imagery, along with engine, aircraft systems, and weapons pages could be called up by either crew member on any of the four displays using programmable bezel buttons. Two smart display units in the new and much larger centre console also enabled the pilot and TACCO/SENSO to enter data and manage communications and navigation functions.

The ITAS Hands-On-Collective-And-Stick (HOCAS) design was intended to give the pilot access to all tactical data, and a multi-slew controller enabled the TACCO/SENSO to steer sensors and display cursors to bring up selected data. A digital dataloader transferred flight plans created on a ground-based mission planning system to the aircraft. Built-in test functions within the ITAS isolated faults down to the circuit card or black box level.

Crucially, a new digital Automatic Flight Control System (AFCS) was developed for the SH-2G(A) to meet the RAN's requirements.

Point of Difference

Its important to understand some of the differences between the SH-2G(A) flight control system and that of other versions of the Super Seasprite. All SH-2D, -F and -G models are controlled by the standard helicopter tail rotor and a unique system of servo-flaps - small aerofoils on the trailing edges of the main rotor blades which are used to alter the pitch of the blades. There is a direct mechanical linkage between the servo-flaps and the cockpit controls – the cyclic pitch and collective lever. The tail rotor also incorporates a mechanical linkage to the pilot's foot pedals in the cockpit.

The system incorporates hydraulic boost to reduce the control forces, and the SH-2F and -G also have an analogue flight control computer known as the Automatic Stabilization Equipment (ASE) to improve handling qualities and automate the execution of standard manoeuvres. Although the SH-2G's FCS was a single-strand, or simplex, system with no redundancy built in, it has served faithfully with the US Navy and other users for 1.1 million flight hours.

The ASE helps the aircraft maintain heading, Doppler airspeed, and barometric or radar altitude. With its dipping sonar, the Egyptian Navy's SH-2G(E) (ordered during the early-1990s) also introduced a digitally augmented ASE able to fly an automatic approach to a coupled hover so that it could lower the sonar transducer into the water, maintain its position above the transducer based on measurements of the angle of the transducer cable, and then fly an automatic departure from the hover.

The new all-digital AFCS for Australia's SH-2G(A) variant replaced the old ASE with a Hamilton Sundstrand digital flight control computer whose software was written by Kaman. Although still a single-strand system this was intended to reduce crew workload still further, enhance the reliability and expand the functionality of the Super Seasprite flight control system. It was designed to fly the aircraft through an automatic approach to the ship or to a search-and-rescue hover, and fly it over a programmed course. It would also maintain set heading, altitude, and airspeed for point-to-point navigation. The flight control computer takes inputs from the SH-2G(A) Inertial Navigation System (INS), Global Positioning System (GPS) and Air Data Computer (ADC) among other sensors.

Although the new AFCS replaced the ASE, the flight control configuration remained the same, with a direct mechanical linkage between the servo-flaps and tail rotors and the collective and cyclic pitch controls and foot pedals in the cockpit.

The failure modes and lack of redundancy in the Super Seasprite's hydraulic or ASE systems were never considered a problem because the pilot can fly the entire flight envelop without them, even though the control forces are higher – and it's understood US Navy pilots would routinely do this for training purposes. In USN operations, had a fault occurred in either the hydraulic or ASE systems, the crew simply turned the system off and continued with the mission.

This was understood to include actuator 'hard overs' (an errant flight control actuator making an uncommanded move to an extreme position) that is reported to have occurred from time to time in US Navy service, though reportedly with little drama - the crew simply turned the system off and got on with the mission. But this occasional tendency became the cause of considerable concern to the RAN and the ADF's airworthiness authorities, as we shall see.

Both US and Australian sources have confirmed the original contract for the SH-2G(A) accepted the premise that the original US Navy type certificate for the Super Seasprite and its flight control system was acceptable to the RAN at that time.

While the Super Seasprite was a logical choice of platform in its weight class, it was a 1950s design. Progressive upgrades had been funded and managed by the US Navy. Kaman had never had sole responsibility for managing the development of an all-new avionics architecture and flight control system. Furthermore, Australia's new SH-2G(A) configuration was drawing the aircraft further and further away from its design roots, with serious implications for its airworthiness type certificate which the project appears not to have considered at this stage. Both the company and the DMO were steering into (for them) uncharted waters, and there are signs Defence wasn't using its own processes correctly to navigate through them.

OPC program founders
In October 1997 Australia's OPC program foundered when the Malaysian government announced that German shipyard Blohm+Voss had been selected for the OPV contract.

At a stroke much of the justification for the RAN's OPC was destroyed. The program was formally terminated in 1998 but effectively died the moment the Malaysians selected the German patrol boat design.

Termination of the OPC program required Project Sea 1411 to be re-examined by the FSPPC and, if it couldn't be justified, to be terminated also. Regardless of the fate of the OPC, however, the Anzac frigates needed a helicopter to help them deliver their full operational potential; some in Canberra advocated cancelling the contract with Kaman, and Sikorsky received informal encouragement from some quarters of the RAN to submit an unsolicited proposal to Defence's Deputy Secretary Acquisition & Logistics to supply more Seahawks.

However, the company erred badly in pricing the aircraft too high because, despite the fact that the Super Seasprite was an all new and different helicopter type with all the attendant risks, and the overhead costs associated with logistics support and aircrew and maintenance training, it was considerably cheaper than the Seahawk for the capability it offered. The FSPPC considered it represented very good value for money.

The authors understand the FSPPC also received technical advice from elsewhere within the Defence organisation that the risks associated with the new ITAS system were low. It has proved impossible to verify whether this advice was in fact provided, and whether it referred to the technical challenges of developing the ITAS or to the cockpit workload issues associated with a two-man crew, but two separate sources state this advice was provided to the committee.

Regardless, when the FSPPC made its decision to stick with the Super Seasprite it appears not to have been warned of the real risks associated with developing the ITAS and AFCS (indeed, one Australian source has expressed surprise that no formal risk assessment appears to have been completed). Therefore, endorsing the Super Seasprite was not a difficult choice for the FSPPC and seems to have been made in good faith and with good intentions.

But with the benefit of hindsight it was a huge mistake. This was the pivotal decision which eventually resulted in the waste of $1 billion.

This is now the official Defence view. The DMO's Head of Helicopter Systems, Major General Tony Fraser, told a Senate estimates committee hearing in July 2008 Seasprite was being procured for a particular sized ship. "That project was then cancelled. It was not pursued," he said. "To me that would be an appropriate gate review point to determine as to whether the project would or would not have been continued."

It became clear quickly that the options to acquire further helicopters wouldn't be exercised. Sea 1411 would deliver only 11 helicopters – and they would still be equipped with the new ITAS and AFCS. Using the embarked/ashore aircraft arithmetic cited above, this means that the RAN would have been pushed to sustain more than four or five aircraft embarked on Anzac frigates at any one time.

In February 1998 Defence signed a $79 million contract with Kongsberg under Project Sea 1414 for the initial batch of Penguin missiles and support; this was followed a year later by a second contract worth $76 million and the announcement that the new-generation 'insensitive munition' warheads for these weapons would be manufactured in Australia by ADI Ltd (now Thales Australia). In March 1998 the $110 million contract for the FLIR and ESM was signed.

Meanwhile work on the airframes and engines got under way at Kaman's plant at Bloomfield, Connecticut; at the Paris Air Show in June 1999 Kaman announced it was flight testing the new AFCS on an SH-2G and that the prototype SH-2G(A) was now on the assembly line. It predicted the first delivery in the final quarter of 2000, with the final aircraft due for delivery in 2002, while the first New Zealand aircraft, complete with APS-143 radar, FLIR Systems Inc thermal imager, Litton Amcon countermeasures suite and AGM-65 Maverick missile capability was expected to roll out at the end of 1999.

By March 2000 the Australian specialist defence and aerospace media was reporting that the SH-2G(A) had completed 13 flights using the first 'builds' of ITAS and AFCS software, and flight testing was expected to continue through early-2001.

These early software 'builds' provided enough control and communications functionality for initial fight testing; the second ITAS software build was then under development at Litton's Software Integration Laboratory in California; this was due for delivery late in 2000, while the second build of AFCS software was due to start flight testing in September of that year.

It's not known what standards and benchmarks were used to evaluate the ITAS software, but one T&E veteran comments that it appears an ADF manual, DEF(AUST) 5679: The Procurement of Computer-based Safety Critical Systems, seems not have been followed. A US industry source close to the ITAS program commented that the original contact didn't mandate compliance with any specific standards in the original contract; however, a number of requirements and standards were invoked later in the program, in some cases after aircraft had been delivered, when it was far too late to integrate these into the software development process.

Similarly, US industry sources cannot recall any formal RAN or Defence A&L risk assessment being carried out at the start of the program, though there are painful memories of risk assessments carried out between 2003 and 2006, and especially so after the April 2005 Sea King crash on Nias Island.

Schedules had quickly begun to slip and as early as October 1999 internal audits by Defence were warning of delays in the ITAS and flight simulator elements of the project and noting the lack of some critical documentation. There were also emerging signs at this stage that the configuration differences between the SH-2G(A) and earlier models, including the avionics, flight control system and increased all-up weight might present certification issues.

In any event, at this early stage Defence A&L already had cause to warn Kaman about problems with Litton's performance on the ITAS development program.

One US source asserts that Litton was doing everything wrong: it underestimated the magnitude of the task, lost some of its best people to the dot com boom which was then raging across California, it changed management structure several times and so lost focus on many of its programs, and then was acquired by Northrop Grumman, creating further turbulence within the organisation.

Nevertheless, the RAN was at this stage scoping its planned Mid-Life Upgrade (MLU) for the S-70B2 Seahawk and considered adapting the ITAS for this aircraft in order to capture synergies in training and software support. The authors have been told by an Australian source that a RAN/DSTO team visited the US at around this time to study the ITAS and departed unimpressed with what they saw; the Seahawk/ITAS combination was not pursued.

Delay

The first public signs of real trouble emerged in late-2000 when Kaman informed the DMO (as Defence A&L had become) that Litton had run into difficulties and was seeking extra cash to finish development of the ITAS.

By this stage the ITAS enabled crew training and familiarisation, and trials with the RAST helicopter recovery system demonstrated the SH-2G(A) was ready for shipborne operations. But it was clear that full tactical functionality remained some way away.

The first half dozen production Super Seasprites and the first batch of Penguin missiles were shipped to Australia in 2001 to allow ground crew and air crew training and familiarisation. The Super Seasprites were re-assembled and test flown at Kaman's Australian plant near the RAN's Naval Air Station at Nowra but thanks to the ITAS software integration problems they were quite unable to carry out any useful tactical training activities.

The original 2001 delivery date came and went without any aircraft being handed over to the RAN. There was obviously a significant problem with the ITAS and the project had encountered serious delays. Just how bad things were wasn't clear, and media queries were met with an ominous silence from both Canberra and Bloomfield.

The silence was shattered at a 21 February 2002 hearing of the Australian Senate's Foreign Affairs, Defence and Trade Committee.

Air Vice Marshal Ray Conroy, then-head of the DMO's aerospace systems division, told the committee persistent software integration problems in the ITAS would delay service entry until about December 2004.

Worse still, Litton had defaulted on its fixed-price sub-contract to develop the ITAS – Kaman terminated the contract in late-2001 and in November that year appointed two new sub-contractors to finish the ITAS development: Canberra-based CSC Australia Pty Ltd, and Californian firm Northrop Grumman Integrated Technology of San Diego. CSC Australia was already Kaman's principal sub-contractor responsible for developing the SH-2G(A) fight simulator and software support centre at Nowra.

Northrop Grumman would complete development of the Tactical Data Management System and Link 11 data link; CSC would be responsible for developing weapons and sensor interfaces and for integrating these separate elements into a single package.

By February 2002 the DMO had already paid the company some $780 million - nearly 80 per cent of the total fixed-price contract value of $1.017 billion dollars, Conroy said. But so far only six aircraft had been built and these remained in Kaman's possession at its facility at Nowra. The earned value payment arrangements in the contract meant the DMO was obliged to pay as various progress milestones were reached, even if the aircraft couldn't be used.

The DMO's problem was that although it was protected to some degree by a fixed price contract with Kaman, that contract didn't include provision for liquidated damages if Kaman failed to perform adequately. If the company failed to deliver entirely, or if it delivered aircraft significantly behind schedule, the contract provided no means of applying sanctions. There was no way for the DMO to get its money back, or its money's worth, except by holding on grimly and driving Kaman to deliver the aircraft it had promised. Kaman, for its part, need no additional incentive to fix the problems and deliver the aircraft, as Roche acknowledged then and later.

The dilemma for the Australian government was that if it sued Kaman for breach of contract, it might end up without any helicopters at all and so have to start an all-new acquisition process taking several years, Michael Roche, Head of the DMO, explained to the Committee.

Whether or not the contract made provision for liquidated damages, whichever course of action the DMO selected – acquisition of a new helicopter or persevering with the Super Seasprite - would result in project delays and additional expenditure. Unexpressed at the time were the very real fears that legal action could drive Kaman into bankruptcy, which would effectively kill any prospect of completing development of the helicopters in an acceptable timeframe.

This is the point at which, with hindsight, senior players in the Australian defence establishment believed the contract should have been terminated. It's an easy call with hindsight but it wasn't so clear-cut at the time.

"We believe, at this stage that it is better to [continue the program]," Roche told the committee. "Our judgment is that we are more likely to get a result this way, rather than by suing the company and effectively terminating the contract. We have a fairly clear plan emerging of how [Kaman] are going to handle the software deficiencies and …while it is not ideal, it will deliver the helicopters faster than we can get them any other way. We believe that we will get the helicopters and that they will be serviceable and useful."

In the meantime, the DMO received legal advice that the RAN should not fly the aircraft as simple utility helicopters pending the delivery of the full ITAS functionality because this might imply what Roche termed “constructive acceptance” of the aircraft and prejudice any legal remedies open to the DMO in future.

“Put bluntly, the contract is not the sort of contract that we would wish to draw up these days,” he added, with masterly understatement.

Roche told the Committee the DMO believed Kaman and its new sub-contractors had the capability to actually deliver the product, but approval to proceed was conditional on the DMO having full visibility of the software architecture and the development and test program.

Just to rub salt in the DMO’s wounds, deliveries of the RNZN’s Super Seasprites (it had exercised an option to order a fifth) had begun in 2001. These aircraft weren’t equipped with the ITAS, but with a variant of the baseline SH-2G avionics fit. Although slightly delayed, they entered service with relatively little trouble.

Kaman, CSC, Northrop Grumman and the DMO worked to get the Super Seasprites sorted. But the relationships between these players were frequently acrimonious - US industry sources have reported they were less than impressed with the performance of their Australian counterparts, describing one local firm as ‘several orders of magnitude less efficient than [US] industry standards’.

It’s symptomatic of the broken relationships and the lack of trust that came to surround the project that assertions and counter-assertions have flown backwards and forwards ever since. But at the time those acrimonious relationships contributed to a significant loss of faith in the aircraft and the prime contractor which compounded growing suspicions over the reliability and safety of the helicopters’ new ITAS and, in particular, the new AFCS.

Nevertheless, in late-2002 the Super Seasprites were offered to the Chief of Navy (CN) for Provisional Acceptance (PA). This is the milestone at which the CN, based on the advice and recommendation of Maritime Commander Australia (MCAUST) is satisfied that the material and operational state of the equipment are such that it is safe to begin Operational Test and Evaluation (OT & E). The CN refused to accept the aircraft at the level of capability they were displaying at that point.

However, in October 2003 then-minister for defence Senator Robert Hill announced the RAN would take Provisional Acceptance of the eight Super Seasprites then at Nowra to enable flight testing and operational evaluation in what was termed the Interim Training Helicopter (ITH) configuration. This also allowed 805 Naval Air Squadron aircrews and maintainers to start training on the new helicopter prior to delivery of the full operational capability at the end of 2004. This would ensure “a smoother and quicker transition into operational service from mid 2005,” Hill stated.

This is consistent with the view of one senior source who told the authors, “One other problem that we faced was that while we were refusing to accept the first helo, Navy was pushing like mad to get their hands on it - even to the point of standing up the squadron and putting pressure on us to have an aircraft available for the squadron inauguration."

One of the advisors to CN and MCAUST when any platform is offered for Provisional Acceptance is the RAN's Test, Evaluation and Acceptance Authority (RANTEAA). It's not known what advice RANTEAA gave CN and MCAUST about the Super Seasprite in 2002, and then again when it was re-offered in October 2003, but the authors have been told it is most unlikely to recommend the CN should accept operational airworthiness risk if the technical integrity of the platform – including the AFCS - was considered to be deficient and therefore the cause of that risk. RANTEAA's advice would be based on the findings of the flight test program being conducted by the RAN's Aircraft Maintenance and Flight Trials Unit (AMAFTU) and upon DGTA's deliberations and findings regarding certification and airworthiness.

Something must have changed for the better in the project by October 2003. Nevertheless, it's clear now that the SH-2G(A) was in no fit state, according to the RAN's own standards, for Provisional Acceptance as anything like ready to proceed to Operational Testing of a certified system. It's hard, therefore, to determine the grounds on which the aircraft was offered for Provisional Acceptance.

The previously unheard-of ITH configuration wasn't part of the original contract and a US flight test veteran confirmed to the authors it was invented as a convenient device to move the project forward. This configuration included the basic flight systems, with no sensors; but the aircraft was cleared to fly under a Special Flight Permit limiting it to test flights by qualified flight test aircrew following an approved flight test plan, pending award of an Australian Military Type Certificate (AMTC) in 2004, so there was no training value to be had for the squadron at this stage.

Taking flight

For a while, however, it seemed the project was getting past its troubles: in November 2003 the first Super Seasprite deck landings occurred aboard HMAS Warramunga, followed by the first phase of First of Class Flight Trials (FOCFT) aboard HMAS Parramatta in May 2004. But at the end of 2004 the full operational capability still wasn't available. And the loss of an RAN Sea King helicopter with nine ADF personnel on Nias Island in Indonesia in April 2005 thrust the safety of the ADF's helicopter operations under the microscope.

At this stage it was being reported widely that the Super Seasprites couldn't be flown at night or under Instrument Meteorological Conditions (IMC). This was because the interim ITAS software configuration didn't include some of the capabilities required for IMC and night operations; these wouldn't be available until the full capability software was delivered. In the meantime, Defence couldn't certify the aircraft for night/IMC operations.

The Canberra rumour mill suggested that the Super Seasprite's lack of crashworthy crew and passenger seats had become another issue; this was never an RAN requirement at any time during the project, but the lack of these was noted by both the operators and the media and reinforced negative perceptions of the aircraft.

Nevertheless, in late-2004 the aircraft was granted an Australian Military Type Certificate (AMTC) and in May 2005 Defence stated that the radar, Link 11 data link and Penguin missiles had all been successfully integrated with the mission control system. Formal qualification testing of the integrated software was expected to commence in April 2006. Defence anticipated 'Initial Operational Release' of the aircraft with the final operational ITAS software load in about September 2006, with full Operational Release scheduled for the end of OT&E late in 2007.

Grounded

Then came the bombshell: in May 2006 the new defence minister Dr Brendan Nelson announced the Super Seasprites were grounded indefinitely owing to safety concerns over the AFCS, and that their AMTC had been withdrawn.

In fact, they had been grounded since March following two AFCS failures, on 14 January and 14 March, which the authors understand from a senior Canberra source were followed by a third failure on 28 March. The cause and consequences of that third failure have not been revealed publicly.

The first two incidents were definitely caused by AFCS 'hardovers' – an AFCS failure resulting in the rapid movement of a flight control actuator to the end of its travel, which would not have been commanded by the system given the then-current flight conditions. This could be catastrophic, especially at low altitude if the pilot was already under a heavy workload at night or in poor visibility or if the aircraft was close to its power, weight and stability margins. And the new ITAS cockpit layout incorporated a new and much wider centre console: under certain circumstances when trying to take corrective action this could rob the pilot's cyclic control ('joystick' in lay man's terms) of the last six to eight inches of travel. Furthermore, because the cockpit was so cramped, the legs of larger pilots could actually foul the cyclic.

One of these hardovers was traced to a faulty circuit board which had shaken loose from its mounting in the AFCS computer. A more serious problem was a propensity for anomalies in the helicopter's air data computer which fed incorrect signals to the AFCS.

Analysis by software engineers concluded that three incidents in just 1800 flight hours was an unacceptably high failure rate, especially when the severity of the hazard presented by such failures was judged to be potentially catastrophic.

The results of this investigation were presented to a software symposium held by the Directorate General of Technical Airworthiness (DGTA) in 2007 by engineer Helen Carson of the DMO's Sea 1411 project office. A copy of Ms Carson's presentation is available on the DGTA web site (see References); she did not speak to the authors.

Ms Carson found the potential severity of such incidents in the SH-2G(A) could also be compounded by several things. The AFCS specification relied on the pilot to mitigate AFCS failures [a very conservative interpretation of this implies the aircraft needed to be flown "hands-on" at all times; an unwary or inattentive pilot could be caught out]. Flight testing by AMAFTU showed the pilot had insufficient control margin to recover the aircraft during a hardover; furthermore, anthropometric restrictions further reduced control authority. And AMAFTU considered that the recovery process recommended in Kaman's own flight manual was 'counter-intuitive': it required the pilot to disconnect the AFCS via a 'quick disconnect' control and then recover the aircraft manually.

Coming 12 months after the tragic deaths of nine Australians in the Sea King helicopter crash on Nias Island in Indonesia, reports of what appeared to be a systemic flight safety problem with the Super Seasprite were extremely unwelcome. The grounding compounded a significant morale problem which already afflicted 805 squadron at Nowra. Indeed, following a visit to Nowra before the 28 March 2006 flight control anomaly, Defence Minister Brendan Nelson noted privately that he had found morale at 805 squadron as low as at its sister squadron, 817, which had suffered the fatal Sea King crash.

Nelson commissioned a complete review of the project from the RAN and DMO. According to senior sources, Nelson wanted to know three things: what it would take to 'fix' the Super Seasprite and what the implications of pursuing this course of action were for cost, schedule and capability; whether Defence could and should lower its requirements and take delivery of an aircraft more quickly with a reduced capability; and what it would cost to simply terminate the project.

The answers weren't what anybody wanted to hear. It was possible to get the aircraft flying again under a Special Flight Permit, but to restore the SH-2G(A)'s type certificate, the DGTA required a complete re-design of the AFCS so that it conformed with modern airworthiness standards.

The first stage of the process needed the existing AFCS software to be re-written to comply with two military software quality and safety standards, MIL-STD-498 and MIL-STD-882C, and to ensure it didn't act on invalid data from the sensors; the system itself was checked thoroughly to ensure that the data being fed into the flight control computer from sensors such as the air data computer were not themselves at fault. This took just over six months and $1 million, with a successful flight test by AMAFTU in February 2007.

The second stage required a complete re-design of the AFCS so that it complied with the civilian type certification standard for helicopters, FAR 29 (see below for a more detailed description). This was a far more challenging and searching program and required a complete re-write of the AFCS software to comply with the MIL-STDs cited earlier and also with a universally adopted software quality standard for avionics, DO-178B Level A; the AFCS as a whole would need to comply with FAR 29 and would require a DO-178B compliant software Health Monitoring Unit.

The DMO estimated that rectifying the problems and bringing the Super Seasprites up to a safe operational standard was expected to take 29 months and cost well over $100 million; Kaman estimated about $40 million. It would require the DMO to station two engineers in the USA on a full time basis with US Federal Aviation Administration (FAA) oversight of the AFCS redesign program at the DMO's expense. Even so, there was no guarantee this approach would succeed: Carson described it as 'High Risk (cost schedule and technical viability)'. Overall, Defence estimated it would cost closer to $200 million to get the Super Seasprites operational.

There was a strong suggestion – the first, thus far – that Nelson was seriously considering cancelling the project. Certainly, it is known he favoured a fall-back plan: to cancel the Super Seasprites, acquire some ex-US Navy Seahawks, arm these with the Penguin missiles, cancel emerging plans for a mid-life upgrade of the RAN's current Seahawks and operate this mixed helicopter fleet until the middle of the next decade when it would be replaced by an all-new helicopter to be acquired under Phase 8 of Project Air 9000.

So what had gone wrong?

Wrong, or right?

Actually, quite a lot was going right, according to Kaman: the company stated in October 2006 that the final Formal Qualification Test (FQT) of the ITAS software would be completed by the end of November; design certification of the software was only a fortnight away with almost all SH-2G(A) performance requirements met or exceeded. Integration of the Penguin missile and Mk46 lightweight torpedo had been verified through flight testing and drop testing of dummy weapons: the sole remaining test was the launch of a live weapon, something which Defence planned to carry out during OT&E.

In late-2006 one of the Super Seasprites carried out a mock attack on an RAN frigate using its full suite of sensors to detect the target, distinguish it from other ships in company and then go through the full procedure for a Penguin missile attack, except for a weapon launch. The company was forcefully expressing confidence the ITAS was working and said it was confident the Super Seasprites should be ready for operational service once the Stage 1 flight tests were completed in February 2007.

Defence didn't agree, however – right up to the end Defence expressed doubt about the state of completeness of the ITAS software and it's understood the final version of the ITAS software was not even presented to the Commonwealth. The biggest problem, however, was the AFCS and the hardovers it had experienced up to March 2006.

Why had this issue taken so long to emerge?

In fact, it had been bubbling away in the background since the late-1990s, waiting to present itself. The issue was essentially one of confidence in the ability of a single-strand flight control system to be adapted to meet new and more challenging performance and safety requirements than it was originally designed for.

It's not unknown for electronic flight control systems and control actuators to display anomalies of one kind or another. For this reason most modern aircraft have multiple redundancy and graceful failure modes – that is, if one part of the flight control system fails there are back-ups: there is no way a single failure can affect the entire system. The RAN's Seahawks have triple redundancy, or two back-ups, in their flight control systems. If some sort of anomaly or hardover occurs in one of these systems, the other back-ups ensure it doesn't endanger the aircraft.

However, with the Super Seasprite's single-strand system, hardovers had an immediate effect on the aircraft – reportedly, they could result in a rapid and extreme uncommanded roll, pitch or yaw.

Does this matter? In short, yes – but exactly how much it matters was the subject of heated debate by Kaman and the RAN.

Kaman's position is based on the Seasprite family's 1.1 million flying hour service record with the US Navy. According to one US helicopter industry veteran, "the standard mode of operation in the SH-2G community had always been to simply turn off or reset the flight control system when a fault occurred, and because it was accepted that the air crew was the mitigator in flight control computer problems, this issue was never an 'issue'."

Evidently, the rapidity of the onset of a problem was never such that the pilot couldn't correct it in a safe and timely way. Indeed, there was at least one such failure at Kaman's factory in Bloomfield during flight testing with an RAN test pilot aboard the aircraft: this reportedly resulted in an uncommanded pitch change which the pilot mitigated successfully.

According to a well-placed US source, at that time Kaman and the RAN agreed that it was a non-issue; in Kaman's view it only became inflated into an 'issue' over time because of changes in the ADF's airworthiness certification regime between the mid-1990s and the early 21st century.

Years after the event, Australian sources dispute this view. The air data computer anomaly known to have occurred at Bloomfield was reportedly dealt with as a 'one off'; it wasn't suspected that this could be part of a systemic issue with the AFCS, nor that the associated hazard could be magnified by changes in the aircraft's weight and balance.

The RAN's view is simple: the effects of an uncommanded control input, or the failure of a single-strand FCS, while the aircraft is close to its weight and power margins and manoeuvring somewhere near the edge of its flight envelope could be catastrophic. The effects could be compounded in the case of the SH-2G(A) by the two-man cockpit environment.

Imagine for a moment the aircraft is on autopilot under the control of the AFCS, hovering or flying slowly over the sea at 200ft or less at night, and conducting a surface search using its radar and FLIR. Because the crew consists of only two persons, the pilot will be part of the search operation, busy monitoring displays and sensors. To use the language of the US Navy Test Pilot School (whose rotary wing flight test manual draws heavily on that of the Empire Test Pilot's School at Boscombe Down in England) his control of the aircraft will be 'passive', possibly even 'passive hands off', rather than 'attentive' - or 'active', when the pilot is actually flying the aircraft.

If an anomaly occurs which causes an actuator 'hard over' the pilot's response may be too slow to save the aircraft before it hits the sea surface. It depends on how much warning the aircraft gives the pilot (so-called 'rotorcraft response time') and then how quickly the pilot recognises the problem and reacts to deal with it (‘pilot response time’).

A pilot in ‘passive hands off’ mode might take four seconds to notice a problem, decide what to do about it and then act. A pilot in ‘active’ mode might take less than 0.5 seconds. In extreme cases, an anomaly occurring at a critical point (for example, while trying to land the aircraft on a small flight deck at a high all-up weight) could still have catastrophic consequences, even if the pilot is ‘alert’ to changes in flight conditions and the status of the FCS.

To put that in context, a sudden and complete FCS failure on a helicopter hovering at 40ft could see it hit the water within 0.8 seconds if the pilot were unable to take corrective action in time.

To borrow a term from another part of the helicopter world, there is a so-called ‘avoid curve’ – a graph of airspeed against altitude: an aircraft on the wrong side of this curve lacks the combination of altitude and air speed necessary to recover from engine failure. The curve is affected by the aircraft weight and balance and factors such as ambient air temperature.

The same applies to the FCS: an irrecoverable FCS failure should not be possible within the helicopter’s flight envelope – and the flight envelope shouldn’t be constrained unduly by the need to protect the aircraft from the consequences of a single-strand FCS failure. Limiting the flight envelope by creating another ‘avoid curve’ to reduce the aircraft’s vulnerability to the consequences of a hardover wasn’t the answer – if a hardover happened on take-off or landing the consequences might still be catastrophic.

All that said, the wider SH-2G community has been operating its Super Seasprites under exactly these conditions without difficulty for two decades. Is Australia’s aircraft, or the way the RAN operates it, so different?

Yes it is: the US Navy flew its Super Seasprites with a three-man crew – the pilot was not required to do anything except fly the aircraft. He was not distracted by sensor management duties or other tactical concerns. But the SH-2G(A) was flown by a single pilot whose attention might be divided between flying the aircraft and managing part of the tactical task at hand.

Even allowing for the conservative views of some test pilots, this was the guts of the problem: put simply, the disagreement between the RAN and DMO and Kaman was over the likelihood of such an anomaly occurring, and the consequences.

Kaman’s firmly-held view (backed up by the service record of the SH-2 family in US Navy service and elsewhere) was that the likelihood of such a thing happening was extremely low, and that the consequences were relatively benign; it had been demonstrated repeatedly over many years that the pilot would have sufficient time under any circumstances to switch off the AFCS and take manual control.

However, the RAN was operating the SH-2G(A) in a completely different way, and planning to fly it at much higher all-up weights than the US Navy, so had a smaller power margin and therefore less room and time for recovery.

Furthermore, it was operating close to the limits of the lateral centre of gravity of the aircraft: 'asymmetric' flight with a 385kg Penguin missile hanging on one side of the aircraft would shift the centre of gravity towards that side. Any control difficulties caused by an AFCS problem or hardover would be compounded by the altered centre of gravity. And if a hardover occurred when the aircraft was flying at low altitude in a steep bank and close to the limits of its spiral stability, for example, again the RAN test community feared the consequences could be catastrophic.

To the RAN this was unacceptable. To Kaman, however, the RAN's attitude was inexplicable: if the Super Seasprite flight control system had been good enough when Australia selected the aircraft back in 1996 (and had still been good enough for the US Navy at that time), why was it no longer good enough in 2006? Part of the answer lies in the paragraph above; another part lies in the type certification process the ADF expects its new aircraft to undergo.

A short digression on certification

The Directorate General of Technical Airworthiness-ADF (DGTA-ADF) had been following Project Sea 1411 since the late-1990s. When it started looking closely at the SH-2G(A) in around 2003-04, it didn't much like what it saw. The new ITAS and AFCS and its increased operating weight made the SH-2G(A) different enough from its predecessors that parts of it needed to be tested and certified anew before it could be cleared for service.

This was the responsibility of the DGTA-ADF, which maintains the procedural framework for managing the technical aspects of airworthiness for the ADF, including design, maintenance and quality assurance regulation, together with a systematic approach to risk management.

The ADF's airworthiness regime came under scrutiny during the 1990s when a series of accidents involving both fixed wing aircraft and helicopters caused concern within Canberra and more widely within the community.

The most prominent of these were the loss of a RAAF Boeing 707 tanker and its crew off East Sale in 1991, followed by the loss of three Blackhawks and 18 Army personnel in a single crash at a tactical training area near Townsville in 1996. However, there had been earlier accidents involving the loss of Mirage and Nomad aircraft (the airworthiness of the latter was subjected to particular scrutiny on several grounds), and a growing sense that the ADF was losing its grip on aviation safety and airworthiness issues.

Until then there had been two almost separate airworthiness authorities within the ADF: the RAAF's, which embraced the Army also; and the RAN's which had sustained the service through the introduction of helicopters on large and small ships as well as the expansion and then decline of fast-jet carrier aviation. By the mid-1990s it's fair to say the RAN's expertise in maritime aviation, including the engineering and technical airworthiness aspects, had been hollowed out significantly. The extent of this hollowness was illustrated graphically by Project Sea 1411.

Following the Blackhawk tragedy a review of ADF aviation safety by retired Air Vice Marshal Brian Weston resulted in the Chief of Air Force assuming responsibility for both technical and operational airworthiness right across the ADF and establishing the DGTA-ADF. This is part of Air Force Headquarters and is located at RAAF Williams, in Laverton, Vic; its head is the Director General Technical Airworthiness (DGTA), who declined to discuss his organisation's role in the Super Seasprite program for this article.

Under formal delegation from Chief of Air Force (CAF), who is ADF Airworthiness Authority (ADF AA), the Director General is the ADF Technical Airworthiness Regulator (ADF TAR) and the ADF Technical Airworthiness Authority (ADF TAA).

To paraphrase part of the Australian National Audit Office (ANAO) report No. 30 of 2001-02: "Test and Evaluation of Major Defence Acquisitions": Air Force, through DGTA-ADF, is responsible for the airworthiness of all Service aircraft. It implements formal procedures that ensure aircraft introduced into service, or substantially modified while in service, comply with essential operational and technical standards. Safety of aircrew is a particular concern.

The report states: "Air Force relies on contractors to design, develop, test and produce the majority of technical equipment. To obtain assurance that new technical equipment meets requirements, the Chief of Air Force (CAF) has endorsed a set of procedures to monitor and record the technical activities of contractors at significant stages of *design and development* of equipment." (Author's italics)

Responsibility for ensuring Naval technical airworthiness management resides with the RAN's senior aviator, the Commander Australian Naval Air Group, or COMAUSNAVAIRGRP. He is responsible to the Chief of Navy who in turn is responsible directly to the Chief of the Defence Force. Airworthiness assurance is a technical framework, supported by standards, regulations and policies; COMAUSNAVAIRGRP is the RAN's Maintenance Authorising Body (MAB) and Agent for the management of technical airworthiness systems and the assurance of air worthiness; in this role he is responsible to DGTA.

The other major players in this process, as far as Naval Aviation trials and acceptance procedures are concerned, are RANTEAA and AMAFTU. These organisations are independent 'siblings' with complementary roles.

RANTEAA's job, among other things, is to help develop quantifiable measures of capability and performance to be incorporated into project documentation and for later use during OT&E; to advise all relevant authorities on the levels of risk presented by their projects; resolve T&E issues at an early stage, thereby avoiding later and more costly intervention; and schedule internal resources and expertise to permit proper commitment to projects.

Chapter 7 of the CDG's 2006 Defence Capability Development Manual states, in summary, that T&E planning should commence early in the needs and requirements phases of a project to help ensure the foundations for subsequent capability definition and assessment are sound, and to inform the requirements definition process. If a requirement is specified, there must be some way to evaluate the capability later to ensure the requirement has been met.

"T&E can be resource intensive so … should be targeted at areas of risk where the benefits from the information obtained justify the resources expended," this document states. "To … ensure that only the required T&E is conducted, a strategy for T&E must be identified early in planning in order to guide more detailed T&E planning and the subsequent execution.

"When developing a T&E strategy, the objective is to perform T&E where the capability risk demands and as early as the acquisition strategy allows."

This is where RANTEAA is supposed to come in.

The March 2006 edition of the Navy Engineering Bulletin summarises AMAFTU's role: it is authorised to conduct flight testing by CAF through a service release, based upon the outcomes of a formal airworthiness board. Based on this authority, AMAFTU is able to plan, conduct and report flight testing activities as an ADF Flight Test Agency.

Flight testing activities conducted by AMAFTU can range from ground based trials and on flight decks of ships in dock to the developmental testing required to define the Ship-Helicopter Operating Limits (SHOL) for the range of RAN aviation-capable ships, covering not just Navy aircraft but Army aircraft as well. Additionally, testing of air stores (missiles, countermeasures and torpedoes to name a few) is carried out by AMAFTU, with dedicated support from the Air Stores Certification (ASC) department of the Aviation Operational Support Group (AOSG) at RAF Base Edinburgh. AMAFTU is a unique unit in the ADF, offering similar capabilities to the RAAF's Aircraft Research and Development Unit (ARDU), however with a specific bent towards embarked helicopter operations.

To over-simplify somewhat, DGTA determines the airworthiness and type certification requirements a new aircraft must meet, RANTEAA is concerned with the integrity of the engineering and T&E processes required to determine whether the aircraft meets these requirements, and AMAFTU conducts the necessary flight testing to support these T&E and certification activities. In the normal course of events, DGTA and RANTEA should become involved in a new aircraft project at the very start – indeed, CDG and the DMO should seek out their advice and requirements as early as possible.

All military aircraft operated by the ADF require a Type Certificate demonstrating that the aircraft meets specified airworthiness requirements for a given set of operational conditions. When a new aircraft is introduced into ADF service it's the DGTA's job to form a view on the appropriate certification regime for it. In the case of fixed and rotary wing aircraft, the DGTA may recommend basing the aircraft type certification on an existing military standard, or on one of the globally recognised civil standards – typically the US Federal Aviation Administration's Federal Aviation Regulations (FAR) Part 25 for fixed wing aircraft and FAR Part 29 for helicopters and rotorcraft, with allowable exceptions to cover specific military modifications or operations.

The DGTA may also endorse certification by other civilian or military authorities – so-called ‘Recognition of Prior Acceptance’, also sometimes referred to as ‘grandfathering’; this is frequently the case with imported military aircraft and helicopters which already have a military type certificate bestowed by the manufacturer’s parent military airworthiness authority. ‘Grandfathering’ is a convenient way of certifying the airworthiness of components such as the airframe, engines, main landing gear and gearbox which are carried over unchanged from earlier models.

However, where a legacy aircraft has been heavily modified in critical areas to meet ADF requirements, or where the ADF is the launch customer for a new variant of the aircraft with significant differences from its predecessors, the DGTA’s organisation is also required to form a view on whether prior certification of the aircraft is acceptable in this instance. This is decided on a case by case basis. Significant changes in critical equipment such as flight control systems would undoubtedly attract close scrutiny and could result in a new certification process being undertaken and a supplemental type certificate being issued.

The creation of the DGTA in 1998 came shortly after Defence and Kaman signed the prime contract for the Super Seasprite. It’s understood the original contract was signed on the basis of Recognition of Prior Acceptance of the US Navy certification. So a single strand FCS which had flown successfully in US Navy service for 30 years was considered acceptable by the RAN airworthiness authorities in 1996, but when the DGTA began to look closely at the aircraft some years later it’s possible to infer that it felt Recognition of Prior Acceptance of the Super Seasprite’s new AFCS was inappropriate and that the substantially new, arguably developmental, system should be re-certified properly.

The DGTA assumption of authority for RAN airworthiness meant, in the view of one US observer, that the RAN and Sea 1411 project office had no notion of how the requirements for airworthiness certification might change or how a system might need to be designed to achieve such certification. When the contract was signed in 1997 it was based upon the then-current RAN aviation certification manual, AP(RAN)10, and not upon the current ADF Technical Airworthiness Maintenance Manual, AAP 7001.053 – TAMM. And Kaman was under no obligation to comply with the ADF’s Airworthiness Design Requirements manual, AAP 7001.054.

When Kaman pointed out that the rules for certification had changed with the transfer of responsibility to the DGTA, the authors have been told the RAN directed it not to address the potential issues – as one industry source noted, “Probably because they had no idea of the scope of the change - I am not sure they understand the requirements … to this day, frankly.”

The new AFCS was not the only element of interest (and possible concern) to the DGTA. Others were the individual and combined effects of the increase in All-Up Weight, the increased authority of a developmental software-driven flight control system and a developmental cockpit instrumentation and flight management system, and the fact the aircraft may be operating close to the limit of its permitted centre of gravity range. Except for Kaman's own flight test results there would have been no historical data on the reliability and performance of the aircraft under these changed conditions, so DGTA had no basis on which to judge whether Recognition of Prior Acceptance was appropriate. It's clear Defence A&L and Navy did not appreciate this at the outset.

What is puzzling is why these concerns took so long to emerge. As the authors understand it, if Defence had followed its own processes right from the start of the project, these issues should have been identified and addressed much earlier than was the case. The authors understand from a US T&E specialist that Kaman only started dealing with RANTEAA at the time the first ITH aircraft was accepted in 2003. At this time the company was also trying to engage with DGTA through the Sea 1411 project office; that same T&E specialist said it was a difficult process: "DMO, DGTA and Kaman didn't work well together," adding it was apparent that competing and opposing interests were at play.

When the RAN started flying the Super Seasprite in 2003 this was under the terms of a Special Flight Permit which required that the aircraft be flown only by qualified AMAFTU test pilots, observers and flight test engineers, following an approved flight test plan. Under these conditions the SH-2G(A) was able to undertake its first deck landings and FOCFTs in 2003 and 2004. All the while, the project was moving towards the Airworthiness Board milestone at which it would receive its Australian Military Type Certificate (AMTC).

It was at this stage that FAR 29 was invoked as the certification baseline for those parts of the Super Seasprite which needed re-certification. The difficulty for the DGTA, the DMO and Kaman was fairly simple: it's very difficult to certify an aircraft according to FAR 29 unless that aircraft is designed with those regulations and specifications in mind. This was certainly not the case with the SH-2G(A).

A significant project issue which contributed to the eventual failure was the lack of a clear test plan, which should have been created by the DMO at the very start of the program. Major capital equipment projects require an Operational Concept Document setting out how the equipment in question will be used, and why; and a Project Management and Acquisition Plan, which includes a Test & Evaluation Master Plan (TEMP). Without these documents it is impossible to develop a roadmap of test, evaluation and certification activities required to bring the aircraft into service. The lack of these documents was noted by the ANAO in its audit report on ADF Test and Evaluation cited above, and had been noticed by Defence officials as far back as October 1999.

At the time the ANAO audit report on T&E was published, in 2001, the Project Sea 1411 TEMP was still described as an "Early draft, being re-written. The Plan is a framework only." And this at the time originally scheduled for delivery of the first complete aircraft.

Thus there was never a single strategy for drawing together all the loose ends of this increasingly complex project and trying to understand what test results were needed to validate and verify progress of the project and, more importantly, to understand the risks as these emerged and fluctuated with each successive stage.

However, at the time the Project Sea 1411 prime contract was signed, in 1997, the authors have been told this hierarchy of documentation was not required; instead, as a project deliverable, it's understood Kaman produced a Kaman Engineering Specification and Contractor Master Test Plan which included some activities which only the RAN could undertake – deck landings on Australian warships, for example, and the release of live ordnance.

It's understood from Australian sources the Kaman Engineering Specification didn't fully cover the Certification Baseline Description (CBD) for some areas of the aircraft – the CBD is the baseline upon which the type certificate is approved; lack of an appropriate CBD means the area concerned must be re-examined, and possibly undergo re-certification if necessary.

As the project wore on, the authors were told attempts were made to 'reverse engineer' some of the documentation that modern projects would require, but this was never a satisfactory exercise. As far as can be determined, for example, a final TEMP was ever actually published, and the lack of a firm baseline against which to conduct test and certification activities made it difficult for both Defence and Kaman to estimate the amount of work required to complete the job.

The situation within Project Sea 1411 was confused even more by the blurring of distinctions between Development Testing (DT) and OT&E, which are quite separate activities and should be carried out by separate organisations.

Responsibility for DT lies with the DMO – it might be carried out in large part by the contractor as part of the development process, but final testing is done under the aegis of the DMO prior to Provisional Acceptance. OT&E in this context is the responsibility of the RAN and will be carried out after Provisional Acceptance with the guidance and support of RANTEEA. However, if DT isn't completed before Provisional Acceptance, DT and OT&E may end up being conducted simultaneously. This, by definition, is impracticable because DT is likely to affect the configuration of the system on which OT&E is being carried out – and vice versa.

"OT on an un-DT'd system is almost a contradiction in terms," the authors were told by an Australian T&E expert. And there is a resource issue: who pays for DT and any consequential modification and further testing that arises? This potentially places the operating service in an adversarial position towards both the DMO and the contractor.

This is what happened with the Super Seasprite, prompting the question: if DT was still required after Provisional Acceptance, under what terms was Provisional Acceptance undertaken?

Kaman probably had cause for complaint also: among the issues it reportedly had with the program office was that nothing ever got approved. A US flight test veteran with some knowledge of the program told the authors, "Plans, schedules, test results, design reviews, test reports - NOTHING got officially approved throughout the process of developing these aircraft. That was convenient for DMO – they could then later come back (years later in most cases) and say, ‘well, you submitted that report in 2001, but this is 2005 and we have a different view of the requirements now.’ It happened often.”

The situation actually became worse as time wore on, the authors were told. As delays mounted, Defence and Kaman regularly disagreed on what it would take to complete development and certification of the aircraft. Kaman could only base its estimate on its understanding of the work required, and came to the conclusion the Sea 1411 project office had no understanding of the totality of the work required to certify the aircraft in general and the flight control system in particular.

In the view of US aerospace industry observers this probably accounts for the continual growth of the RAN’s own estimate of work required for completion. The situation seems to have been complicated by uncertainty over exactly what provisions were required for final certification.

For example, strict adherence to the FAR 29 Category B provisions applying to the Super Seasprite as this was interpreted by the DGTA might demand the aircraft be fitted with a fully redundant flight control system – section 29.1321 states: “For Category B rotorcraft the equipment, systems and installations must be designed to prevent hazards to the rotorcraft if they malfunction or fail.” In the case of the SH-2G(A) that was deemed to require a re-design of the AFCS to meet standards and requirements which were never envisioned at the time the contract was signed.

An Australian authority on risk management issues told the authors it’s clear Defence A&L did not understand, and had not planned to understand and address, the project’s airworthiness complexities and risk, including the integrity of safety critical software, at the outset; many of these appear to have come to light only after the scrutiny of DGTA. Thus the consequences of procurement decisions were unknown and came as an unwelcome shock to all parties when they emerged.

Many of the certification requirements such as DO-178B-compliant software and FAR 29 are process-based. They require that certain specific tests and procedures are carried out throughout the design and development of the system and its software – implementing these standards retrospectively was nearly impossible once the AFCS and its software had been built and were actually flying.

This resonates with the concept of DGTA procedures “to monitor and record the technical activities of contractors at significant stages of *design and development* of equipment.” Was it actually possible to certify an aircraft under FAR 29 when it wasn’t designed or built to these specifications? Clearly not to the letter of the regulations, it would appear.

That aside, the DGTA also examined other airworthiness and flight safety issues. The design of the Super Seasprite fuel tanks was modified in line with FAR 29 section 29.562 to make them more ‘crash worthy’. And at the time the project was cancelled the DGTA and RAN were examining the issue of whether or not the pilot and co-pilot seats, which were simply bolted to the cockpit rear bulkhead, should be replaced with ‘crashworthy’ seats, as had been recommended previously for the RAN’s Sea King helicopters.

Although not mandatory under FAR 29, if a decision had been taken to install crashworthy seats, this would have required a definition of what sort of performance the seats should have, along with some sort of certification process that takes into account the design of the seats themselves, the design of the helicopter cockpit bulkhead and floor and the effect of any structural changes necessary to accommodate the new seats.

How long would this take? How much would it cost? And was it necessary in any case? In the wake of the Sea King tragedy (in which lack of crashworthy seats was blamed for at least some of the fatalities), and based on the analysis of casualties from the 1996 Black Hawk crash (some of those aboard the aircraft survived because they were sitting in crashworthy seats) then, yes, these would probably have been deemed necessary, resulting in another contract change.

Endgame

It was issues like this, and the authors have been told there were several of them, which finally killed the project. It looks very much as if type certification would have required either too much time, money and work, or too many dispensations from the strict provisions of FAR 29, any of which might be subject to a retrospective challenge in the future if anything had befallen one of the Super Seasprites or a member of its crew.

A US industry observer with knowledge of both the US Navy and RAN airworthiness processes commented: “All the programmatic issues would have been much easier to resolve if the operators - the pilots - in the RAN had a strong desire to field the capability. They didn't. And by 2005/2006, it was clear that the SH-2G(A) was never going to be what they wanted.”

“It had taken too long. It wasn't the ‘shiny new thing’ that they bought in 1997. Meanwhile, the Kiwis just integrated their SH-2G(NZ) into their fleet and got on with it. I suppose there is something to be said for only specifying the capability you can actually manage and understand.

“I would say that the original program was challenging - it stretched the bounds of what had been done in integration in maritime helicopters. But the fundamental issues were not those of integration - they were of failure to recognize the threat to the program that a moving certification baseline posed.”

It’s probably fair to say Kaman’s view was that the Super Seasprite flight control system had been good enough to accumulate 1.1 million flight hours in US Navy service, so the RAN and the ADF airworthiness authorities were nit-picking in an area they didn’t understand.

But Defence was in no mood to take chances, especially after the Sea King tragedy.

Defence was concerned not only with the work required to rectify the AFCS, but also other unresolved issues with both the AFCS and the ITAS. Basically, the RAN was starting to lose confidence in the aircraft and in Kaman’s assertions that the ITAS software was close to completion. There still appeared to be enough ragged edges and loose ends that nobody wanted to take the safety of the aircraft or the ITAS performance for granted, or to take responsibility for guaranteeing its airworthiness to the standard now required. And a meeting between defence minister Dr Brendan Nelson and the senior management of Kaman in late-2006 left the minister with no confidence the company actually understood or acknowledged Defence’s concerns.

The issue seems to have become one also of confidence: nobody really new how long it would take, and what further measures it would take, to restore the RAN’s confidence in the Super Seasprite.

While these issues were debated, the aircraft remained on the ground in a state of preservation and the company was ordered to stop work. Dr Nelson had decided by early 2007 to cancel the project but with a Federal election due later that year he was over-ruled by the Federal cabinet in May on the grounds that such a high profile project cancellation would jeopardise the Coalition government’s electoral prospects. To the surprise of many who had anticipated cancellation he announced on 25 May, “After detailed consideration of the issues involved, the Government has decided to continue the Seasprite project, subject to satisfactory contract arrangements.”

With the government’s decision to press on, Kaman told reporters in May the Super Seasprites would start a final 4-5 week final flight test program around mid-2007. This estimate was flatly contradicted by Defence who stated that, “Due to the meticulous process designed to ensure adequate safety, it is unlikely that Seasprite flying will re-commence before late 2007.”

The 2007-08 Defence Portfolio Budget Statement released that same month stated on page 286: “The main risks to [the Super Seasprite] project include the automatic flight control system issue, mission computer shortcomings, and a lack of customer confidence in the platform brought about by the extended flight suspension and ongoing technical issues. The risks are being managed with the automatic flight control system through a phased remediation strategy.”

The Super Seasprite had become a weeping sore for all parties; the then-Labor Opposition had also made much of the Government’s inability to either sort out the problems and get the helicopter into service, or terminate the project and seek an alternative. When the new Labor government came to power in November 2007 one of its first actions of the new defence minister, Joel Fitzgibbon, was to commission a review of the Super Seasprite project.

In February 2008 the head of the Helicopter Systems Division of the DMO, Major General Tony Fraser, told the Senate Committee on Foreign Affairs, Defence and Trade he didn’t expect the Super Seasprite would enter service before 2011. In the meantime, “We fully expect that, when we get the aircraft flying, given our history to this point we will identify additional issues with [the ITAS] that will require rectification. So that drives a schedule issue as to how long it may take us—and our expectation as to how long it may take us—to bring the aircraft into service.

“There are many issues to confront and work through. So we have identified first of all that the flight control system needed work done. That work has been done and we have that test report. So we will now address whether that meets our requirements and whether we can move ahead with the further modifications to bring it up to somewhere close to contemporary standards at least… to bring some confidence to the aircraft and to the program.

"Given the uncertainty about it, its suspension from flying in April 2006, the considerable adverse media that it has suffered as a result of all of the reviews and all of the issues associated with it, it suffers from a lack of confidence. Therefore, to be able to bring it into service effectively and to meet our obligations of duty of care and safety we need to demonstrate a level of rigour that is probably above what we would normally have to demonstrate and apply."

General Fraser acknowledged the ongoing friction with Kaman over how to achieve certification of the aircraft. "We have had discussions with the contractor about how we might do that. Of course the difficulty is that they have stated that they have run at a loss. It is a commercial difficulty for them and their business, so there is clearly strong friction when it comes to how we might achieve that."

Replying to a question about whether or not it was actually possible to achieve all the capabilities the ADF sought by upgrading the systems aboard a 40-year-old airframe, General Fraser responded candidly, "That remains to be solved. We do not have an agreed position as to whether that is possible. There is high risk that we are not able to meet contemporary standards, no matter what work we do to this aircraft…. I fully understand the need to bring this aircraft, or to get a capability for Navy, into service. But I am not going to do that and I will not take … unreasonable risks for those who fly and operate the aircraft. So I am going to need to be fully satisfied, in order to bring them into service, that we have fully addressed them."

And in the end it was the uncertainty and risk that killed the Super Seasprite: it seemed nobody in the Navy wanted the aircraft badly enough to persevere with it; in any case the 2011 in-service date was still only an estimate – it seemed to many that the development process, software testing and wrangling could have gone on indefinitely.

Consequently, only a few weeks after General Fraser's appearance before the Senate Defence Committee, on 5 March 2008 minister Fitzgibbon announced, "After careful consideration of all the issues involved, the Government has decided that it intends to cancel the project. Discussions will be commenced immediately with the contractor in relation to the legal and financial arrangements to facilitate this."

Later that day on ABC Radio's PM program, Fitzgibbon added, "We have said we will honour existing contracts, but we have also said that common sense must always prevail, and where it's clear that the safety of the aircrews couldn't be guaranteed and it was clear that the capability was never likely to be delivered, that there was no real choice here but to terminate the project."

However, at the time Fitzgibbon did not provide a single, clear technical, operational or safety-related reason why the project was cancelled, and nobody in a position to do so has provided a reason, either. That's not to say such reasons don't exist, but there seem to have been many of them, not all necessarily insurmountable but formidable in the aggregate. And the major parties to this program are bound by confidentiality agreements, so the full picture may never emerge.

It's fair to say the SH-2G(A) Super Seasprite died in the detail, and with it $1 billion of Australian taxpayers' money.

Wash-up

There were two converging requirements which dictated the RAN's choice of the Super Seasprite: the need for a lightweight (6 tonne) helicopter able to operate off an OPC; and the need for a helicopter capable of carrying the Penguin Mk2 anti-ship missile.

The Penguin requirement is logical and defensible: the weapon offered a formidable capability which would add considerably to the reach and flexibility of the Anzac frigates. The US Navy had already armed some of its own Seahawks with Penguin missiles by the time Sea 1411 got under way and Anzac ships have demonstrated they are quite capable of operating a 10-tonne S-70B Seahawk. Acquiring more Seahawks should have met the RAN's requirements in a potentially low-risk manner with an aircraft that would have provided important synergies in logistics support and aircrew and maintenance training, regardless of the avionics and weapons fit selected- particularly if, as some have suggested, the RAN had taken the opportunity to re-align the configurations of its Seahawks with those of the US Navy.

The OPC was a pointless but extraordinarily damaging digression as far as the RAN is concerned. It made no operational sense and it distorted unnecessarily the RAN's view of its aviation requirements. The OPC requirement drove the helicopter weight down. In its weight class the SH-2G(A) was the only contender able to come close to the RAN's performance requirements. The OPC requirement emerged in 1991 and died a mere six years later. If it was so easily killed, how could it be so easily born? This suggests a failure in Defence's processes.

Committing to a helicopter acquisition project when the outcome of the OPC/OPV program was still uncertain was rash: this exposed the Commonwealth to unforeseen and unmanaged risk. With hindsight it's clear that RAN support for the OPC project was ambivalent: was it appropriate, therefore, to allow the OPC program to drive Project Sea 1411 when there was still uncertainty over whether or not the OPC project would go ahead as originally planned? No.

It's important to note, however, the FSPPC did also consider cancelling the Super Seasprite after the cancellation of the OPC project. Endorsement of the original decision in favour of the Super Seasprite was reinforced by the significant difference in price at the time between this aircraft and the Seahawk and, it has been suggested, flawed advice that the risks were slight. As noted earlier, Defence now acknowledges this was the point at which the project should have been examined more thoroughly.

It is clear from this entire episode that the capability development and higher level decision-making processes of the ADF and Department of Defence were inadequate, and that political considerations were allowed to dominate these processes to a damaging degree.

The major technical problems with this project stemmed from the requirement for a two-man crew. The existing SH-2G avionics architecture wasn't designed to handle and present tactical and navigation information in a way that enabled safe, efficient two-man operations. The only way to achieve this was to develop an all-new, integrated avionics architecture from scratch.

The cost, schedule and technical risks associated with developing an all-new avionics architecture for a fleet of 30 such aircraft – the maximum envisaged if the OPC project had gone ahead - would be hard to justify. Assuming these risks for a fleet of just 11 aircraft was a massive mistake. Given the RAN's previous difficulties bringing into service 16 S-70B2 Seahawks which also had an Australia-unique mission system, choosing to repeat this process with the SH-2G(A) represents a bizarre failure in Defence's risk management and capability development processes at that time, from the project office right up to the senior committee level.

And according to T&E professionals, there's evidence policy guidelines on the management of project risk were not complied with, even after deficiencies in this regard were highlighted by the ANAO and by internal reports and audits.

To create a totally integrated weapon system required that the ITAS be integrated with an all-new AFCS which would in turn replace the existing, proven flight control system. It is clear that the people who drew up the user specifications for the SH-2G(A) lacked any understanding of the cost of creating this new capability, and lacked the skills to make credible, shrewd trade-offs between cost, capability and risk.

The software development and integration and flight safety and type certification issues involved were daunting. It's clear nobody with the power to influence the outcomes understood the costs and risks involved, nor the challenges in bringing these aircraft safely into service.

Defence therefore ordered the wrong aircraft for all the wrong reasons, in spite of advice – both verbal and written – to the contrary.

It's not clear Defence has actually learned from some of these costly lessons: the recent cancellation of Boeing's prime contract to supply a Tactical UAV (TUAV) system for the Army under Joint Project 129 has some uncomfortable echoes of Project Sea 1411.

The ADF, which had never operated a TUAV before, could have ordered a TUAV system, consisting of a number of unmanned aircraft and ground control stations, off the shelf from manufacturers which have been producing them for several decades. These would have provided a more than adequate operational capability and immediate interoperability with our most important allies at low risk.

However, faced with a choice between two TUAV Systems in production or under development for the US and British Armies, Defence chose instead to become the launch customer for an all-new, developmental TUAV with an elaborate and expensive ground control system which was unique to Australia. The system specified by Defence couldn't be delivered under the contract it signed with the prime contractor.

The blanket term "Defence" is used deliberately in this context – if poor judgement or a bad decision by one part of the organisation cannot be challenged and overturned, if necessary, following analyses by other elements of the defence organisation, then this implies a malaise across the organisation as a whole.

Returning to the Super Seasprite, some level of systemic dysfunction within the organisation is evident from the authors' research: Defence A&L and Australia's naval aviation community more broadly seem not to have understood these risks, nor the costs associated with operating a fragmented fleet consisting of small numbers of diverse aircraft types – and nor, crucially, the technical airworthiness implications of the extensive engineering modifications made to the original design in order to satisfy the RAN's operational requirements.

Given the technological risks involved, not enough attention seems to have been paid to pre-project risk-mitigation, including proving the technological feasibility of the ITAS/AFCS element; similarly, little attention seems to have been paid to some key design considerations: design to cost, reliability and 'produceability'.

Nor was there any understanding of the risks associated with making Kaman the prime contractor for this project. Kaman is a small company which manufactures a good aircraft. It entered into the contract in good faith, and with plenty of faith in its product; but it is not a prime systems integrator, and had no experience of managing a large complex integration program, nor a large, complex sub-contractor such as Litton. It's also clear Litton badly underestimated the cost, complexity and risk associated with the ITAS program and was a critical contributing cause of project failure.

It is noteworthy that two recent major helicopter programs have seen the airframe manufacturer acting as sub-contractor to a prime systems integrator – these are the US Navy's MH-60R Seahawk, and the Royal Navy's Merlin HM1; in both cases Lockheed Martin is the prime contractor and prime systems integrator. Ironically, the MH-60R is a contender to replace both the S-70B2 Seahawk and the Super Seasprite in RAN service.

Project Sea 1411 has been described by one observer as a 'notoriously closed shop': very little useful information seemed to leak out of its Defence A&L and then DMO project office, and it's not clear to this day exactly when some of the difficulties discussed above actually became evident to the project office. Nor is it clear what action was taken to address them at the time – the unavoidable impression looking back is one of incoherent drift. DGTA scrutiny seems only to have compounded this by creating another layer of uncertainty and complexity.

It is arguable that, if the ITAS had worked as advertised and the aircraft had been delivered on time in 2001, the Super Seasprite would not have been subjected to the same scrutiny and certification struggles and might have been judged a success. This ignores the fact that the real 'show-stopper' was the AFCS. As early as October 1999 there's reason to believe the DGTA and the RAN's OT&E authorities were becoming concerned at the type certification implications presented by the AFCS and other aspects of the SH-2G(A).

This isn't to suggest the SH-2G(A) is in any way a dangerous aircraft: the service record of the SH-2 family demonstrates quite the opposite. But the aircraft wasn't designed to do the things the RAN was asking of it: Project Sea 1411 took both the SH-2G(A) and Defence well outside their respective comfort zones.

And this seems to be what finally killed the project: while it wasn't a 'dangerous' aircraft it seems to have been impossible to prove that it was 'safe', in the sense that it could achieve type certification in Australia based on the provisions of FAR 29 in any sort of economical and timely process.

The analogy is somebody buying a 40-year-old classic car and then insisting that the vendor prove that it complies with modern day automotive design and safety regulations. This is impossible – but it doesn't mean the car is dangerous, unroadworthy or undesirable.

For Defence – for the Minister, the Chief of Air Force, Chief of Navy, DGTA, DMO and RAN – the prospect of an accident involving an SH-2G(A) Super Seasprite, and the possibility that its likelihood, or consequences, might have been magnified in some way by an issue relating to technical airworthiness was too frightening to contemplate. In the wake of the Sea King tragedy Defence had no stomach for unquantified and unjustifiable risk.

The legacy of this project is extensive. Defence's capability development and acquisition processes have undergone wide-ranging reform. But in a project of this kind much of the inherent complexity resides at its front-end, in the domain of the Capability Development Group. This is where user requirements must be developed and tested rigorously against things like White Paper guidance and threat assessments; and where realistic functional specifications are drawn up and, again, tested rigorously for their cost, schedule and technical risk implications.

As noted by Mr David Mortimer in his 2008 Defence Procurement and Sustainment Review, the CDG generally lacks the full range of skills needed to plan a multi-billion dollar acquisition program. He calls for increased resources for both CDG and the DMO to improve their cost and schedule estimating and project management abilities, and for the two to work more closely together at the early stages of major capital equipment projects. It's worth adding here that a smart buyer would ensure he has the engineering and operational expertise necessary to identify potential certification and flight safety issues from the very outset.

The changes in the ADF's technical airworthiness regime after the prime contract had been signed were a welcome improvement in this critical area of ADF capability, but they compounded the project's difficulties by an order of magnitude: the aircraft which the ADF appeared to be demanding in 2006 was not the aircraft which Kaman tendered to manufacture back in 1996. However, it's clear the RAN and Defence A&L didn't really understand what they were asking for in the first place.

And it's not clear that a contract which included provision for liquidated damages would have made much difference to the outcome as far as the Commonwealth government is concerned. Suing Kaman for the full value of the project would have driven it to bankruptcy, to the benefit of nobody. This would not have corrected the mistakes made earlier, nor recovered lost time.

As former DMO chief Mick Roche noted in February 2002, "Put bluntly, the contract is not the sort of contract that we would wish to draw up these days."

Quite: getting it wrong has cost Australian taxpayers $1 billion, while the capability this money was meant to acquire won't now enter service until Phase 8 of Project Air 9000 delivers new maritime helicopters some time in the second half of the next decade – 20 years after Sea 1411 got under way and at a further cost of $3.5 billion.

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ENDS

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