The Kiowa Navigation Rationalisation Project (KNRP)

Revitalisation of an Ageing Aircraft

A Project Managers Perspective

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Abstract

The Australian Army Bell 206B-1 helicopter (Kiowa) was introduced into service in the early 1970's and the navigation and avionics systems were based on predominantly older, analogue technology. Over the years the aircraft avionics systems had become increasingly unreliable and difficult to support. In addition to the obsolescence issues faced with the Kiowa avionics system, it was also poorly suited to the provision of lead-in training for complex aircraft types with advanced avionics such as the MRH-90 Multi Role Helicopter, CH-47F Chinook Helicopter, and the Tiger Armed Reconnaissance Helicopter (ARH).

The Kiowa is currently planned to be withdrawn from military service in 2015 and will be replaced with an aircraft procured by Project Air 9000 Phase 7, The Helicopter Aircrew Training System (HATS). HATS is intended to provide a rotary wing training capability for the Australian Navy and Army to meet the future rotary wing training needs of the Australian Defence Forces (ADF). The Kiowa will continue to be the lead-in helicopter trainer for Army until replaced by the HATS aircraft.

This paper[1] provides an insight to the issues associated with the ageing avionic systems fitted to the Kiowa and focuses on the design realisation and the challenges faced in fielding the upgrade introduced by the Army Minor Capital Project AMP015.50, the Kiowa Navigation Rationalisation Project (KNRP). The KNRP modified aircraft will be used to conduct helicopter Army pilot training at Oakey, and continuation training at Holsworthy until it is withdrawn from service.

[1] **Disclaimer:** This paper is not to be construed as an Academic Paper. It is only intended to provide the Project Managers perspective and does necessarily reflect the views and/or opinions of other individuals, contractors, or ADF agencies involved throughout the project.

The Macquarie Dictionary defines ***Obsolescent*** as:
1. becoming obsolete; passing out of use, as a word.
2. tending to become out of date, as machinery, weapons, etc.

Introduction

The Army Bell 206B-1 helicopter (Kiowa) has been around for nearly 40 years and had not been subject to any significant avionics upgrade in it's entire life, and to suggest that some of the navigation equipment fitted to the Kiowa had become obsolescent is an understatement. The navigation equipment fitted to the Kiowa, and in particular the marker beacon receiver, had become very hard to support and required urgent attention.

In Feb 09 the Kiowa Navigation Rationalisation Project (KNRP) was approved by Government to fit the ADF Kiowa fleet with an upgraded navigation system. The ageing systems replaced by the KNRP upgrade include:

- ***R-1041/ARN Marker Beacon*** – The Marker Beacon system provides an aural and visual (light) indication when the aircraft has flown through a directional beam that indicates range to the end of a runway.
- ***AN/APX 72 IFF Transponder*** - The Identification Friend or Foe (IFF) System was conceived during the WWII to enable friendly aircraft to be identified by surface and aircraft forces. Following the end of WWII, the use of IFF was adopted by civilian air traffic control for the identification and tracking of aircraft within controlled airspace. Because of the automatic nature of the receiving and transmitting of signals, the term transponder has been adopted to identify the combined receiver/transmitter unit. The purpose of IFF is to provide an automatic reception and transmission of data to allow accurate tracking of the aircraft by various radar systems for air traffic control purposes. The system is capable of replying to various interrogation signals that are known as Mode 1, Mode 2, Mode 3/A & Mode C.
- ***Collins R-1388/ ARN-82 VOR Receiver (includes Localiser)*** - The VHF Omni Range (VOR) radio system determines the aircraft's position with reference to a VOR station and provides a means of following a chosen heading towards or away from a VOR station. The localiser provides a visual (fly left-fly right) display of the position of the aircraft relative to a straight approach line to the runway.
- ***ID- 998/ASN Radio Magnetic Indicator*** - The Radio Magnetic Indicator (RMI) displays a direct readout of navigation information from the ASN-43 Compass System as well as VOR and Directional Finding (DF) navigation information.
- ***ID-1347 Course Indicator*** – The Course Indicator (CI) allows the pilot to select a VOR bearing and provides course deviation to or from that bearing. It also provides course deviation for the Localiser when on an approach to a runway. The CI is capable of providing Glideslope (fly up–fly down) information during an approach; however, the Kiowa was not fitted with the Glideslope capability and used the deviation bar to display FM Homing information.
- ***M10 Attitude Indicator*** - The Attitude Indicator (AI) displays flight attitude of the helicopter relative to the earth. Pitch attitude is indicated by the vertical motion of the sphere with respect to the miniature aircraft. Roll attitude is indicated by rotational motion of the roll pointer with respect to the fixed roll scale located at the top of the display.

Kiowa Instrument Panel prior to the KNRP upgrade

Justification

The following factors were used as justification to proceed with the upgrade:

- **Supportability and reliability.** A number of Kiowa navigation and avionics components had become increasingly difficult to support. The marker beacon had already become unsupportable and cannibalisation was being employed to keep the number of aircraft required serviceable. The Mode 4 Identification Friend or Foe (IFF) system was also becoming difficult to maintain and its military capabilities are no longer required for the Kiowa. The Transponder was extremely heavy and could be replaced by a less complex, lighter civilian transponder.
- **Weight reductions.** The removal and/ or replacement of older equipment, particularly the Mode 4 IFF, would decrease the weight of Kiowa (initial estimate was as much as 100 lb). Lower aircraft weight would increase aircraft performance, reduce aircraft fatigue and marginally reduce operating costs. The reduced weight could also be expected to reduce the frequency of heavy landings sometimes experienced during training sorties.
- **Aircraft communications, navigation & surveillance (CNS) and air traffic management (ATM) trends.** It is anticipated that the Australian Civil Aviation Safety Authority (CASA) will be phasing out and reducing the quantities of a number of ground-based navigation aids including Marker Beacons, Non Directional Beacons (NDB) and VHF Omni Range (VOR) systems. The navigation and instrument approaches associated with these aids will be replaced with Global Navigation Satellite Systems (GNSS) technology, which requires aircraft to be fitted with the appropriate avionics.

- ***Lead-in skills training.*** The Army Aviation ARH pilot courses have been designed to take a pilot trained on "old build" standard Kiowa directly onto an ARH course. Experience showed that pilots who have flown aircraft with advanced avionics are more likely to successfully complete ARH, MRH-90 and CH-47F training with reduced flying hour requirements. Kiowa will continue to be the lead-in helicopter trainer until at least 2015 for more complex aircraft types including ARH, MRH-90 and, for a shorter time, the CH-47F.

The complex nature of the ARH instrument panel highlights the need for a suitable aircraft to conduct lead-in training for it and similar aircraft (MRH-90 and CH-47F).

- **Safety of flight.** The modified aircraft would provide navigation and avionics capabilities that would reduce pilot workload, enhance situational awareness and improve safety. Automatic Dependent Surveillance - Broadcast (ADS-B) functionality would be included as part of KNRP. ADS-B equipped and enabled Kiowa's would automatically transmit identification, pressure altitude, position, velocity vector, and vertical rate data for use by air traffic control. ADS-B will enable the Kiowa to operate in future air traffic management systems.
- **Kiowa withdrawal date.** On current planning Navy and Army (through Major Project AIR 9000 PH 7) would receive the new helicopter training aircraft commencing not sooner than 2015.

Systems Introduced by the Upgrade

The design change is primarily the integration of Commercial of the Shelf (COTS) equipment. The equipment selected is well-developed, includes the required functionality and U.S. Federal Aviation Administration (FAA) certifications, and is in common use in many civilian aircraft.

KNRP introduced the following equipment to the Kiowa:

- **Dual *Garmin GNS-430W GPS Receivers*** (TSO[2]-C34e, C36e, C7d, C38d, C40c, C113, C146a, & C194 compliant) providing:
    - Moving map Global Navigation Satellite Systems (GNSS) with a Jeppesen programmable database;
    - Two data (Nav Data & Terrain Data) cards (only Nav Data enabled);
    - VOR/Localiser receiver (Configured for one receiver only - replaces the current Rockwell Collins system);
    - Glideslope (Configured for one receiver only – new capability).
    - VHF AM radio (Configured for one receiver only - replaces the current VHF-1, AN/ARC-186 radio); and
    - Cross connection for transferring data between GNSS receivers in the event of unit failure.
- ***A Sandel SN-4500 Electronic Horizontal Situation Indicator (EHSI)*** (TSO-C3d, C4c, C6d C34e, C35e, C36e, C40c, C41d, C113, C118, & C119b compliant) providing:
    - Radio Magnetic Indicator (RMI) function (replaces the current AN/ASN-43 RMI),
    - Course Select Indicator (CSI) function (replaces the Course Indicator ID-1347), and
    - Capable of displaying annunciation and moving map information from the GNSS.
    - Glideslope and Localiser deviation bars.
    - Reversionary Mode Option which has been enabled but not yet used – can be used provide attitude and heading reference information when connected to ARINC 429 data source.
- ***A Sandel SA4550 Electronic Attitude Indicator (EAI)*** (TSO-C3d, C4c, C34e, C36e, C52b, C113 compliant) providing:
    - Attitude reference,
    - Electronic slip and skid, and
    - On-screen annunciators.

[2] Technical Standard Order (TSO) - is a minimum performance standard issued by the Administrator for specified materials, parts, processes, and appliances used on civil aircraft.

- ***A Garmin GTX330ES Mode S Transponder*** with ADS-B Out capability (TSO-C166a, compliant).
- ***A L3 AI-350 W Attitude Indicator (AI)*** (TSO-C4c compliant) to provide:
    - Alternative/Stand-by attitude reference system; and
    - Alternative slip indication.
- Various annunciators for GPS integrity, Terminal, Message, Approach and waypoints.
- Various remote annunciators to indicate the selected navigation source on the EHSI.
- ANVIS[3] (Class B) compatible cockpit lighting.
- An ANVIS (Class B) Night Vision Goggle (NVG) Compatible Warning and Caution System.

Modified KNRP Instrument Panel

[3] ANVIS – Aviator's Night Vision Imaging System

Design and Installation Effort

A navigation upgrade of the Kiowa was initially developed and trialled by the Army Aviation Systems Program Office (AASPO) in 2006; however, during the initial testing the Air Force Research and Development Unit (ARDU), the ADF flight test agency responsible for Army Aircraft, identified a number of shortfalls with the configuration. It was clear from this testing that the design would need to be significantly changed to address these issues.

Taking into consideration ARDU's concerns, in 2008 Sikorsky Helitech Pty Ltd located at Pinkenba in Brisbane, as an Authorised Engineering Organisation (AEO) for the Army Kiowa was contracted to develop the modification for KNRP. In accordance with the ADF Technical Airworthiness Regulatory Framework, the KNRP upgrade was assessed as a 'Major' Change to the Type Design requiring Supplemental Type Certification (STC) on the basis that the system upgrade would enhance the aircraft capability. This was the first Major design change managed by AASPO. This meant that considerable effort was required on the part of Sikorsky Helitech and the AASPO to ensure that the evidence was available for consideration by the Technical Airworthiness Authority (TAA) and Operational Airworthiness Authority (OAA) for the recommendation for certification and issue of an STC by the ADF Airworthiness Authority.

AASPO provided Sikorsky Helitech with the technical data and lessons that had been learned from the initial prototype, and from the very outset, AASPO provided technical assistance and input into the design, based on experience and detailed knowledge of the aircraft. Without this technical assistance and the close working relationship between AASPO and Sikorsky Helitech, the KNRP project would not have been successful.

The design was completed in stages and included Preliminary and Detailed Design Reviews. A Deviation (approval to trail the modification) was issued to modify aircraft A17-011 as the first KNRP aircraft. The aircraft was delivered to the Sikorsky Helitech facility at Pinkenba where it was stripped down and prepared for the modification. The prototyping process was a relatively long process, primarily due to the complexity of the modification and the number of old items being removed and new items to be installed.

Some of the major aspects of the modification involved removing the aircraft instrument panel and installing a new, slightly larger one, designed specifically for the new instrument layout. Two GPS antennae were installed, one mounted to the cockpit roof and the other halfway along the tail boom. Dual GPS units were installed into the instrument panel along with a new electronic HSI, Attitude Indicator, Transponder and Standby Attitude Indicator.

It was important that Sikorsky Helitech liaised closely with AASPO during the prototyping phase and the respective project managers kept regular contact to ensure any potential problems that could delay the project were addressed immediately. AASPO continued to provide Engineering and Logistical support where possible to keep the project on schedule.

Once the modification had been completed on the prototype aircraft, a detailed test regime began. The tests covered basic ground functional tests, Electromagnetic Interference and Electromagnetic Compatibility (EMI/EMC) testing, Human Machine Interface (HMI) tests, Night Vision Imaging System (NVIS) testing and flight testing. Due to higher priorities ARDU, the organisation that had performed the testing on the original prototype aircraft, was unavailable to carry out the acceptance testing for several months and in order to maintain the project schedule, the Navy's Aircraft Maintenance and Aircraft Flight Trial Unit (AMAFTU) was approached and requested to assist with the Human Machine Interface (HMI), NVIS assessments, and detailed flight testing. This required careful planning as AMAFTU was not authorised to test Army aircraft, and after due process, the ADF-Airworthiness Authority provided approval for AMAFTU to conduct Acceptance Flight Testing for KNRP in Feb 09.

The KNRP Prototype Aircraft (A17-011) Undergoing Ground Tests at Sikorsky Helitech

NVIS compatibility testing involved both indoor static and night time flight testing at Woomera. The outdoor tests required a specific ambient light and therefore required the moon to be a certain phase in order to be able to carry out the testing correctly. Sikorsky Helitech provided engineering and maintenance support throughout the Acceptance Flight Testing. Acceptance Flight Testing was completed in Jun 09.

NVIS Testing Hangar at Woomera

Kiowa Aircraft undergoing KNRP Modification at Sikorsky Helitech

After completing prototype testing of the KNRP configuration, the modification was approved and 27 aircraft have now been installed with the KNRP upgrade at the Sikorsky Helitech facility. The competence and professional manner of AASPO, AMAFTU, Sikorsky Helitech and other organisations involved with the design and acceptance testing phases has greatly contributed to the delivery of the project outcomes within a relatively short time span.

Challenges faced during the Design and Installation Activity:

Installation schedule – *Aircraft modification stagger and alignment with training program.*

Flight Test Agency availability – *Justification to utilise AMAFTU proved to be invaluable..*

Signal interface related issues – *Analogue to digital.*

Disturbance of existing wiring looms – *Ageing aircraft.*

Non KNRP related unserviceabilities - *Identified during and after installation.*

Stakeholder management – *Some wanting to build brick walls.*

Staffing levels within AASPO – *Too much work not enough people… stress levels increased.*

Venues – *Different contractors: modification program versus training support.*

Certification Activities

Certification was considered a critical aspect of the KNRP. To successfully obtain the granting of the Supplemental Type Certificate and achieve Service Release of the KNRP capability, a co-operative environment between key Commonwealth stakeholders and Sikorsky Helitech was required. This needed to be in a controlled environment and therefore, the project adopted a staged certification strategy comprising of three stages:

- **Stage 1.** Certification of the Design Change;
- **Stage 2.** KNRP capability Operational Evaluation (OPEVAL) under a Special Flight Permit (SFP); and
- **Stage 3.** Issue of Supplemental Type Certificate and Service Release.

Stage 1 - Certification of the Design Change. Certification activities were completed in accordance with the KNRP Project Design Acceptance Strategy (PDAS) that was developed by AASPO and approved by the ADF Technical Airworthiness Authority. Predominately the strategy relied on Sikorsky Helitech as an Authorised Engineering Organisation (AEO) for the ADF Bell 206B-1 to provide an Approved Design in compliance with the requirements of the ADF Technical and Operational Airworthiness Regulations for a Major Design Change. Design Acceptance is a Commonwealth responsibility and was carried by AASPO's Chief Engineer as the Design Acceptance Representative for the ADF Bell 206B-1. Products for the certification purposes included, but were not limited to:

- Project Design Acceptance Strategy
- Design Specification
- Compliance Matrix
- Modification Instruction
- Maintenance Procedures
- Weight and Balance calculations
- Electrical Loads analysis
- Technical Drawings
- Structural Analysis
- Ground and Flight Test Plans
- Ground and Flight Test Reports
- Systems Safety Program
- Functional Hazard Analysis
- Systems Safety Assessment
- Safety Case Report
- Hazard Log
- Technical and aircrew publication amendments
- Training Needs Analysis
- Training Package
- Accomplishment Summary
- Airworthiness Management Plan

Challenges faced during Certification Stage 1:

Very steep learning curve - *First time for a 'Major' change to a Type Design at AASPO.*

Personnel changes in key organisations external to AASPO – *Expectations change.*

Time to get everything done – *There was only 24 hours in a day.*

So much paper work – *Where is that Plan/Report?*

People resources - *Minor Projects don't come with additional personnel resources.*

IFR certification - *Incorrect assumption made and identified as an issue at the 11th hour*

Expectation Management – *What is it you really /want?*

Stage 2 – Operational Evaluation. The initial project strategy was to progress the KNRP directly to Supplemental Type Certification (STC) and Service Release (SR); however, discussions between key ADF stakeholders concluded that it would be more appropriate to operate and evaluate the KNRP capability under a Special Flight Permit (SFP) for a limited period of time. This strategy will allow the stakeholders (Capability Manager, Army Aviation Training Centre, and AASPO) to properly assess the continued airworthiness aspects associated with operations and logistics support arrangements of the KNRP upgrade, prior to issue of an STC and SR.

A crawl, walk, run strategy was adopted for the Operation Evaluation, and in Oct 2010 a Special Flight Permit (SFP) was issued by the ADF Airworthiness Authority to allow the Army Aviation Training Centre to conduct an Operational Evaluation of the KNRP capability. An Operational Evaluation Plan was implemented and the evaluation was conducted in two phases:

- **Phase 1** - Qualified Flying Instructors were trained and gained experience in operating KNRP modified aircraft.
- **Phase 2** – Validation and development of in-flight curriculum for ab-initio trainees and gap training for extant Kiowa pilots, and the conduct of the first ab-initio pilot training course on KNRP.

The Operational Evaluation was completed in November 2010.

Challenges faced during Certification Stage 2:

Paradigm shift from Analogue to Digital- *We've always done it this way so this can't work.*

Reluctance to take on responsibilities – *Too many chiefs not enough indians.*

Time Management - *Leaving things to the last minute… I thought you were responsible for that.*

Unexpected unserviceabilities - *Bath Tub curve……incorrect operation of equipment.*

Stage 3 – Supplemental Type Certification and Service Release. Upon completion of the Operational Evaluation, Supplemental Type Certification and Service Release was sought simultaneously through endorsement by the Kiowa Airworthiness Board in Dec 10. Supplemental Type Certification and Service Release was granted by the ADF Airworthiness Authority for the Design Change in February 2011. IFR Certification is still pending.

Challenges faced during Certification Stage 3:

Getting everything completed in time - *Airworthiness Board date was set in concrete…not a bad thing.*

Personnel changes in key organisations external to AASPO –*Different interpretation/expectations…again.*

Stakeholder Management – *continuously herding the cats to establish a consolidated position.*

Risk Management

A key to success for any project is the ability to identify and manage risks. AASPO, realising the importance of a robust but dynamic risk management system specified the development of a Risk Management Plan (RMP) to be one of the first project deliverables. The RMP was developed by Sikorsky Helitech in consultation with the AASPO and delivered as part of the Preliminary Design Review (PDR) package. The RMP defined all aspects of the KNRP risk management system including, lines of communication and responsibilities, methods for identifying and capturing risk, risk rating and prioritising mitigations. Communication between Sikorsky Helitech and AASPO underpinned the successes achieved, and open and frank discussions were held regularly. Design and project management decisions were made effectively, by taking the schedule and cost impacts into consideration.

As the project continued, the RMP was updated as required and the significant risks were conveyed to all stakeholders through a monthly Project Status Report. If risks required immediate action, meetings or teleconferences were convened to minimise or negate the impact as early as possible.

Regular dialog between the Sikorsky Helitech and AASPO Project Managers provided constant updates on the status of identified risks and ensured early identification of new risks. The early identification of new risks arising from regular dialogue allowed for less drastic mitigation strategies. A trusted relationship was formed, based on open discussions where all parties felt that their input was valued. Risks were seamlessly identified, assigned, mitigated and monitored.

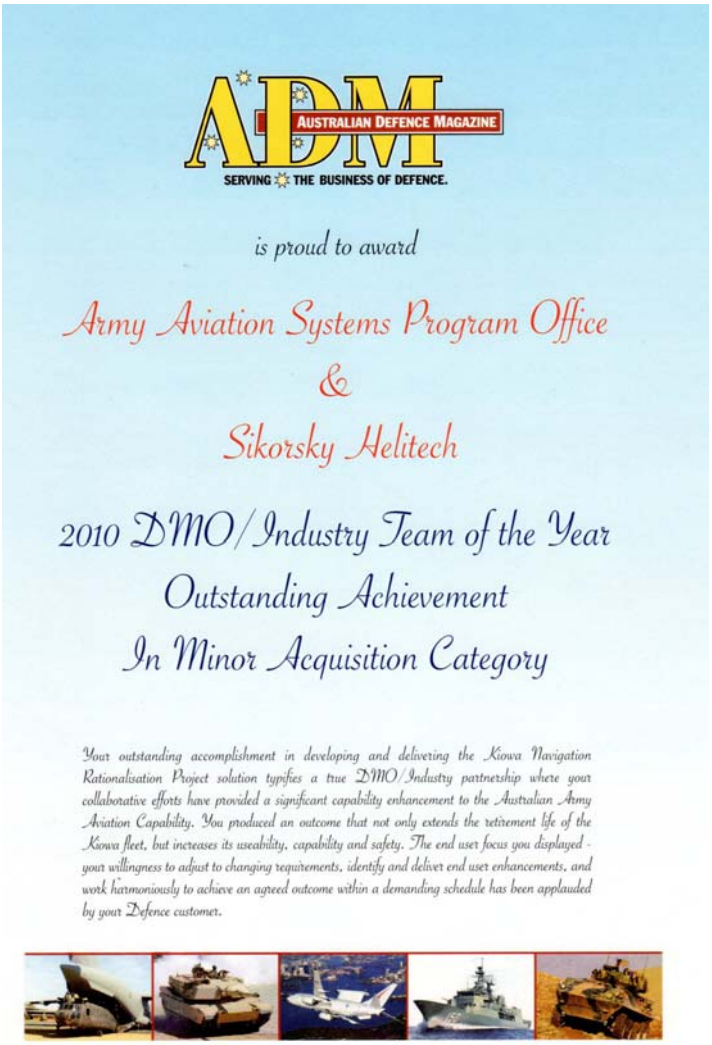
All these factors combined to ensure that all relevant stakeholders were aware of the risks impacting their work, clear in their responsibilities in mitigating the risks and at a project level, the ADF and Sikorsky Helitech Project Managers were confident that all risks had been identified and treated.

A One Team Approach

The success of the project can be attributed to the effort of many agencies; however, the working relationship between AASPO and Sikorsky Helitech was instrumental in achieving a great outcome in a relatively short period of time. The trusted relationship between the Sikorsky Helitech and AASPO has been a constant throughout the project. This has enabled open dialogue which instilled an ethos of finding innovative win-win solutions to issues cooperatively rather than apportioning blame and expecting the other to fix the problem.

A close collaborative team was formed with Sikorsky Helitech in support of Airworthiness Board activities as a result of this project. Open and frank communication is considered paramount in Airworthiness Board forums, which is illustrated through the mandated assignment of a chairperson independent of the service chain of command. Sikorsky Helitech supported AASPO in providing extensive technical expertise and background at all Airworthiness Boards held for the duration of the project.

A measure of the ownership by both organisations was shown in the quick and effective response to issues. High priority was given to those issues likely to impact the Army Aviation Training Centre capability. AASPO and Sikorsky Helitech constantly adapted to changing schedule requirements of the Training Centre brought about by unscheduled changes to training courses. This commitment to the capability rather than to blindly deliver to the contract clearly demonstrated that both AASPO and Sikorsky Helitech were focused on delivering the improved capability outcomes rather than just aircraft without a cause.



Key aspects and achievements throughout the project included:

- Win – win solutions constantly found;
- Formal communication channels defined and effective;
- Trusted team environments allowed for informal communication;
- Rapid response to questions;
- Ethos of find a fix rather than excuse;
- “Open Door” policy to all stakeholders;
- Risks communicated freely; and
- Mutual trust developed and sustained between AASPO and Sikorsky Helitech throughout the project.

The efforts of AASPO and Sikorsky Helitech was recognised when the project was nominated, and won, the ADM Outstanding Achievement award for the 2010 DMO/Industry Team of the Year in the Minor Acquisition Category.