AUSTRALIAN ARMY AIRBORNE RADIO DIRECTION FINDING

Introduction

This Annex not only gives the history of the operational use of Airborne Direction Finding (ARDF) by 547 Signal Troop (547 Sig Tp) in South Vietnam, it also covers the origins of the equipment and the research, development and manufacture conducted by the Weapons Research Establishment (WRE)[1].

Figure 1: WRE[2]

[1] WRE is located at Salisbury, South Australia, adjacent to RAAF Edinburgh. WRE was formed in January 1955 after an amalgamation between the Long Range Weapons Establishment and several other Defence research facilities. The Establishment consisted of five wings; the Weapons Research and Development Wing, the Applied Physics Wing, the Engineering Wing, the Trial Wing and the Administrative Wing. In April 1978 the Establishment was divided into four laboratories, which were known collectively as the Defence Research Centre and this was later changed to WRE. WRE is now known as the Defence Scientific and Technology Organisation (DSTO).

[2] http://www.dsto.defence.gov.au/discover-dsto/our-history

HISTORY

Pre-Vietnam.

In 1962, 101 Wireless Regiment's[3] 201 Signal Squadron (201 Sig Sqn) that was located in Singapore, deployed a Troop size detachment on Exercise Trumpeter that was exercising in the Triang area in Malaya. Exercise Trumpeter involved the entire 28th Commonwealth Brigade Group exercising for Vietnam type operations. The Detachment was to act as an enemy Sigint/Electronic Warfare (EW) unit.

To supplement its intercept activities and provide the location of target units, the Troop had two AN/PRD-1 HFDF sets in its inventory. In the main, the results from the PRD-1 were unsatisfactory as the equipment was more suited for open terrain operation, and transmitter locations derived were very suspect. To provide more accurate DF, the Squadron Officer Commanding Major Colin Cattanach and senior technician Corporal Roy Grace devised a system that could be used in an aircraft.

The system consisted of a small National brand commercial short wave HF radio with a directional ferrite-rod antenna, with audio piped to a flying helmet. The following photographs show a similar radio and the operator with the makeshift DF equipment ready for flight.

Figure 2: National Commercial Radio

[3] Later retitled 7 Signal Regiment.

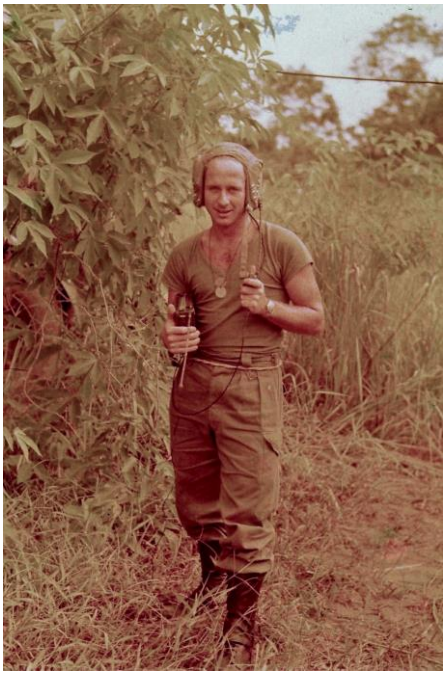


Figure 3: First ARDF Operator (Roy Grace) before flight

When in the aircraft the operator would listen out on pre-planned frequencies until a signal was received. When the target was active the operator leant out of the aircraft window/door and rotated the radio until the loudest signal was received. The antenna rod pointed to the approximate location of the transmitter.

The British Army Auster aircraft was used as the airborne platform.

Figure 4: Auster Aircraft

Results were pleasing. Although it did not give an accurate location the operator and pilot were able to plot the approximate location of the transmitter on a map and pass this information back to the Troop.

This was the first known ARDF system to be used by the Australian Army and considered to be the genesis of future development.

PROJECT HIGH DIVINE

When 547 Signal Troop (547 Sig Tp) deployed to South Vietnam (SVN) it had to rely on US ARDF sources for support.

It was quickly realised that integral ARDF support was an essential requirement for the Troop. The relevant section within Army HQ in Canberra (MI8), (Colonel Ken Whyte and Major Colin Cattanach), placed a research task on WRE to develop an ARDF system capable of being installed in the current Australian Army fixed wing Light Aircraft operating in SVN, the Cessna 180D. The project was allocated the cover name 'High Divine'.

Figure 5: Cessna 180D

Initial Development Trials

It has not been identified when the initial tasking was placed on WRE. However, the R Treharne[4] produced Technical Memorandum CPD(T) 169 dated April 1969[5], contained the following paragraph:

The first development trials were carried out in South Australia in February 1965 and successful operational trials were made in August 1967. Although intended for experimental demonstration only the Australian equipment was so successful that it has been pressed into operational service ever since.

Figure 6: Extract from CPD(T) 169

It can therefore be presumed that WRE was conducting ARDF trials before 547 Sig Tp deployed to Vietnam.

[4] WRE Scientist.

[5] See Appendix 1.

Following extensive research, development and trials at WRE, and then field testing in SVN during July and August 1967, the first Australian experimental ARDF equipment went into operational service at the end of August 1967.

Aircraft Equipment and Procedure

The system deployed was very basic and the main equipment comprised two RA-217 communication receivers, a Rustrak Recorder[6] and control panel. The antenna fitted to the aircraft for DF was a retractable long wire antenna that had to be extended when the aircraft was airborne and rewound before landing.

Fitting the equipment into the Cessna involved removing the co-pilots (right) seat and installing an equipment rack containing the receivers, Rustrak Recorder and control module. The ARDF operator sat behind the equipment in the right hand rear seat.

As mentioned above, the initial system was very basic and the operation was based on the Rustrak Recorder, recording on paper, the received signal strength of the target transmitter along at least two, preferably three, tracks.

The following photographs show a Rustrak Recorder and what the paper tape output would look like after a DF run.

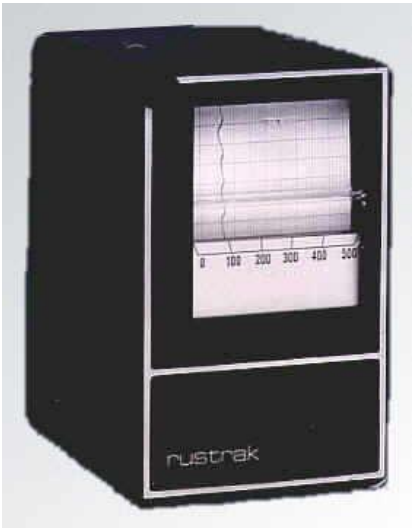


Figure 7: Rustrak recorder

[6] **Rustrak Recorder**. A general purpose, one pen, 2-5/16" strip chart recorder for DC voltage and current. It uses pressure sensitive chart paper.

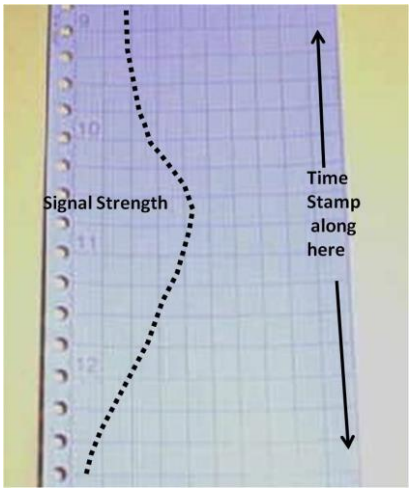


Figure 8: Paper trace example

Provision of Aircraft
The aircraft used by 547 Sig Tp were provided, maintained, and flown by 161 Independent Reconnaissance Flight (161 Recce Flt). Normally there were two fixed wing aircraft in SVN, and one was always allocated to the Troop.

ARDF Equipment Arrives
The authors have not located any files that indicate when the High Divine equipment arrived in Vietnam, However, based on when Major Colin Cattanach and Ross Teharne[7] were in-country, the equipment most probably arrived in mid-October 1966.

ARDF Trials in Country
The ARDF Trials were carried out In SVN during the period 23 October to 5 November 1966 with Jim Rayner and Clarrie Day being the operators sitting in the rear of the aircraft. The trials were not completely successful, but a rudimentary system was available. More development was required back at WRE.

Mission Preparation
Pre-Mission. ARDF missions would normally be timed around known priority target schedule times. Before departing on a mission the ARDF Operator would be issued with a task list by the Troop Intelligence staff. He would roughly map out the area of operation, where the aircraft should be located, and if possible, direction of flight paths when targets were intercepted.

Pilot Briefing. Before take-off the operator would brief the pilot on the areas that the aircraft was to fly. This would normally include a central area known as a frag point, where the aircraft could circle between known schedules for the operator to conduct general search and hopefully find new transmissions and possibly obtain a fix.

[7] WRE Scientist, participation not confirmed.

On aircraft warm-up, the pilot would contact Nui Dat Artillery Control to see what fire missions were in progress and, if possible, future artillery missions. This was necessary to ensure that the aircraft would not cross over fire lines. During the flight the pilot would be in constant contact with other artillery controls that were responsible for the area where the aircraft was active.

Obtaining a Fix

In the target area, while circling at approximately 2000 feet above ground level, the ideal operating altitude of the equipment, the following procedure was the norm:

- **Aircraft Location.** The pilot would be continually relating map to ground to identify features that can easily be located on a map.
- **Target Acquisition.** When the operator detected a target on his receivers he would ask the pilot to start a run/track and on a certain heading.
- **Start point.** The pilot would immediately stand the aircraft on a wing hopefully pointing the wing at a reference point then flare out over the start point and signify "time on" to the operator.[8]
- **Rustrak Recording.** The operator would start the Rustrak recorder and start the stop watch.
- **Track and Speed.** The pilot would fly the aircraft at a constant altitude and speed. The ideal speed was 110 knots.
- **Rustrak Display.** When the operator confirmed that the recorder had displayed a line showing an increase and then decrease in signal strength, he would then tell the pilot to stop the run.
- **Stop Point.** The pilot would then attempt to find an end point under the aircraft that he could relate to the map. When an end point was reached the pilot would tell the operator “stop”, and the operator would stop the Rustrak recording and the stop watch. The pilot would inform the operator the start and finish grid references and the heading of the aircraft and the operator would record the elapsed time.
- **Additional Tracks.** The pilot would try to fly at least two legs (tracks) at different headings to obtain another cut. The more legs flown the better result. Three legs were preferred.

Note:

During the run, the operator was normally able to determine what side of the aircraft the transmitter was located, thus making the direction of the 2nd and 3rd leg more appropriate.

Unfortunately, the results could not be plotted until the operator returned to the Troop.

[8] Electronic on-board navigation aids were considered early in the ARDF concept/development phase. All that was available in the mid 60s was the Doppler system and the Inertial Guidance Platform (IGP). The IGP was ruled out almost immediately because of the cost (over $250K at the time), and the Doppler (weight 50KG) was also ruled out as it couldn’t be accommodated in the Cessna 180.

Plotting. On the ground the operator used a plotting board where start and end point grid references could be inserted to replicate a map. On the board the operator would plot where the loudest signal relevant to the aircraft's time along the track was, and intersecting lines would give the probable location of the transmitter.

The following graphic is an example of how a plot may look on a map with Rustrak traces shown as an example run. The transmitter would be reported as being located in the centre of the fix triangle with a CEP[9] e.g. YS 369715 1000m.

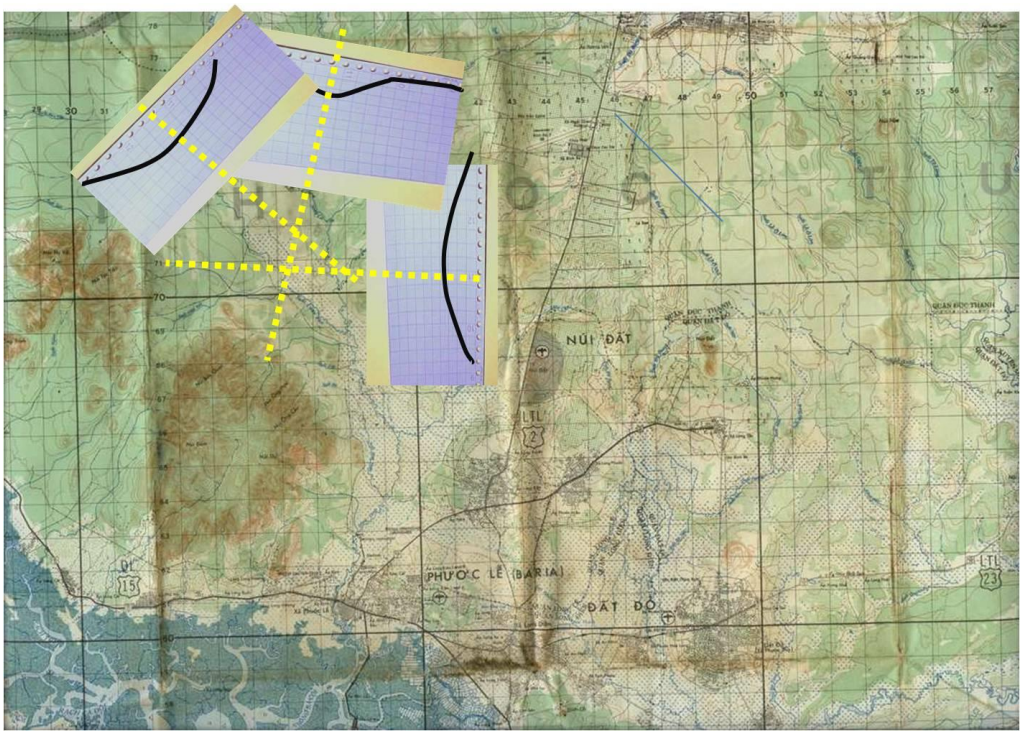


Figure 9: Example of an ARDF Rustrak Plot

Reporting. All ARDF results were immediately reported to the Troop Processing Section and by flash or immediate precedence signal to other Sigint agencies.

[9] CEP = Circular Error of Probability.

NEW EQUIPMENT

WRE scientists continued developing the ARDF system at Adelaide, and another experimental system was delivered to SVN in September 1967 for trials. This system had the new ferrite rod antenna fitted[10]. If the trials were successful the new system would be retained for operational use.

Fortunately the trials proved successful and in October 1967, the experimental version became operational, and remained in constant use until another prototype for fitting in the Pilatus Porter arrived in late 1969.

The following photographs shows the experimental equipment installed in an aircraft at WRE during development and trials.

Note:
There was only one complete equipment available.
There was no full back-up.

[10] In February 1968, M Raymond of WRE produced a WRE Technical Note CPD (T) 145 titled *An Airborne Radio Direction Finder*. (NAA: D4884, CPD(T) 145). The CPD was summarised as "*A simple radio direction finder, for use in light aircraft, as described. A detailed description of the system is given, together with circuits and waveform diagrams*". Concluding Remarks:
From the experience gained with the two experimental models, an engineered version of the direction finder could be built. This should be basically the Model B circuit with the following additions:

(a) Reintroduce the switching to connect one aerial continuously to the receiver, for tuning.
(b) Use of tropicalized plug in boards for all circuits.
(c) Provision to illuminate the equipment for night operations.

Another possible modification would be to mount the wide band amplifier in the copper box within the fibreglass housing. This amplifier could be replaced by a single integrated circuit having the required gain, bandwidth, and noise performance.

Figure 10: Prototype ARDF Equipment in Cessna 180b Aircraft

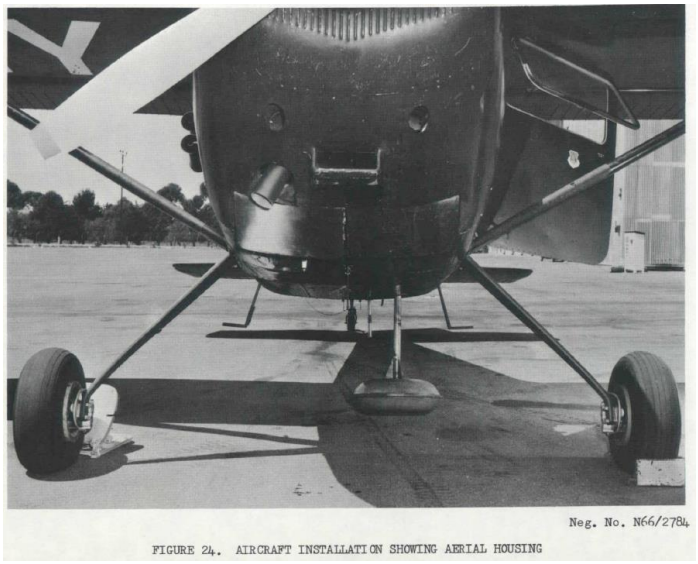


Figure 11: Antenna Pod[11]

The basic enhancements to the original ARDF equipment were a new antenna system (including goniometer), receivers[12], control panel, timing clock and an audio assembly for connecting the operator's headset to the intercept receivers and in-aircraft audio.

The main change to the airframe was that a hole had to be made in the fuselage of the aircraft behind the pilot's seat to accommodate the antenna [later changed to behind the

[11] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F61

[12] The receiver in Model A shown in the photograph at Figure 9 not identified.

passenger's seat and closer to the centre of the aircraft][13]. This involved extensive testing before being passed by the RAAF and Army authorities. When taking off, landing or on the ground the antenna pod was raised as it would protrude close to the level of the tyres.

The new experimental equipment rack was similar to the following photograph[14]:

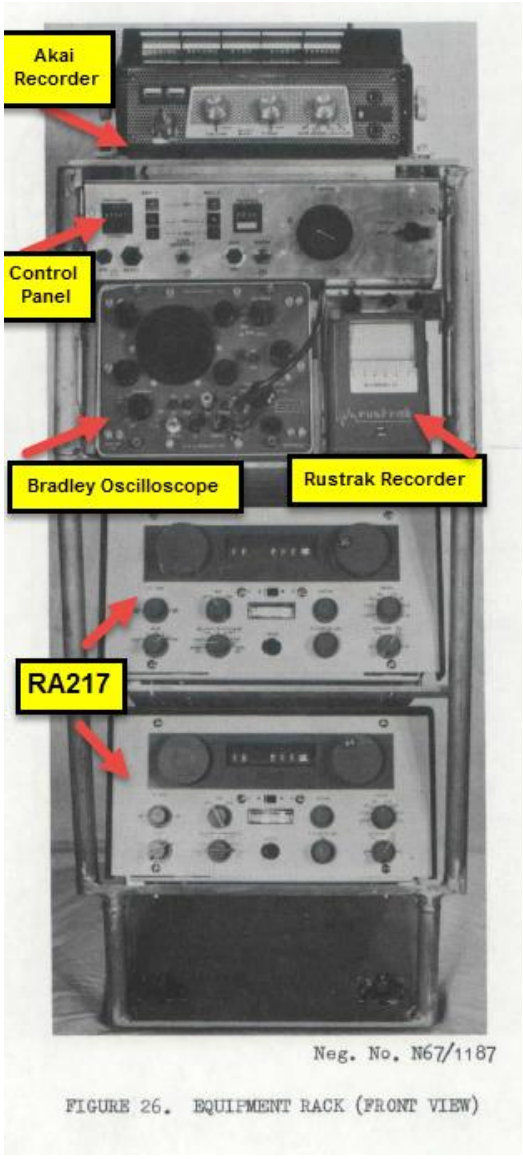


Figure 12: Prototype Model B #1[15]

[13] The operator's area was very cramped. The bench seat next to the operator held the communications equipment, webbing back pack (containing target information, code books, and stationary), water bottles, operator's weapon and at least one bandolier of ammunition.
[14] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F59.
[15] Ibid, F59.

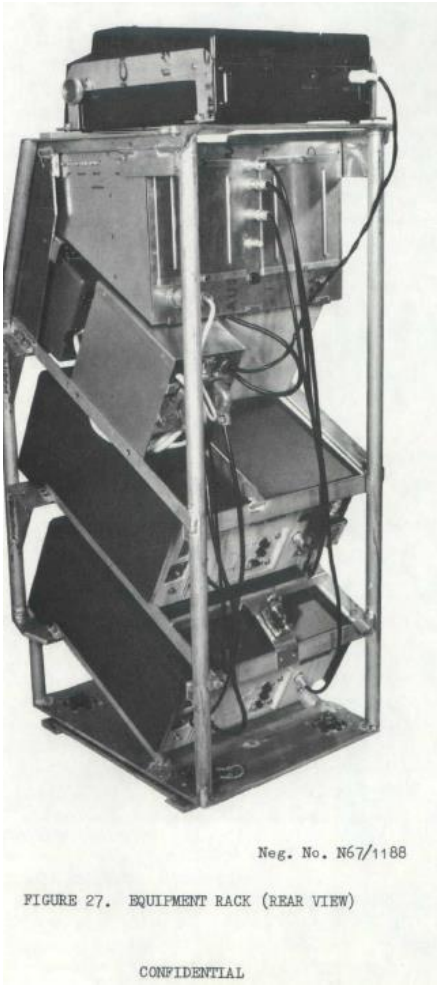


Figure 13: Prototype Model B #2[16]

The rack consisted of:

- **Retractable Antenna Array.** The array comprised two horizontally polarized, Adcock configured, helically coiled, ferrite rod antennas – mounted 60 degrees from each other and 30 degrees either side of the centre line. The array was rotatable through 360 degrees and was housed in a fiberglass radome which could be retracted when not in operational use.

[16] Ibid, F58.

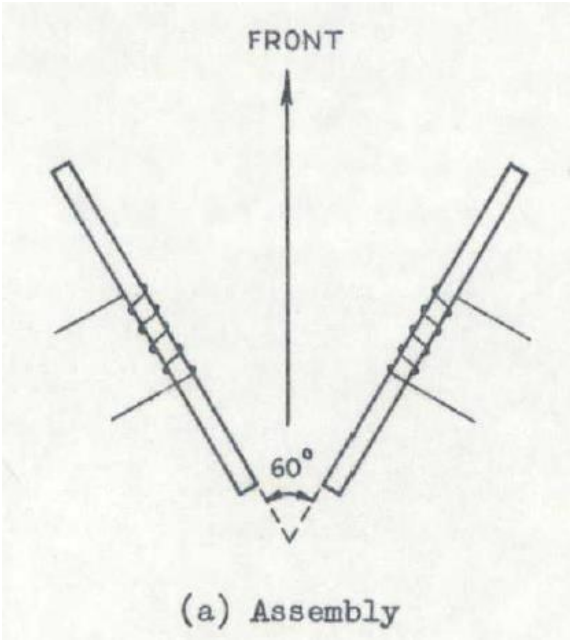


Figure 14: Ferrite Rod Assembly[17]

- **System Control Unit.** As well as providing inter-connectivity options, this unit housed system timers, antenna pre-amplifiers, and a cyclical antenna switching device which alternatively connects each DF antenna to the RF input of the Slave RA-217 DF receiver.
- **RA-217 Search Receiver.** This unit is connected to a HF long wire or whip antenna. As well as providing audio to the operator, it also provides an RF output to the Rustrak chart recorder.
- **RA-217 Slave DF Receiver.** This unit is connected to the DF antenna array and its RF tuning is slaved to the Search receiver. It provides an RF output to the Tektronix Type 422 CRO.
- **Tektronix Type 422 Cathode Ray Oscilloscope (CRO).[18]** This provides a visual image of relative amplitude of the RF signal received by the DF antennas. It is displayed in the sequence left, right, left, so each antenna amplitude is displayed side by side (see explanatory diagram). When each antenna displays equal amplitude, the centre line of the antenna array is pointing directly at the DF target transmitter. *(When the operators became more experienced they could tell by size of the picture how close they were to the target and at times were able to completely overfly the target.)*

[17] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F91

[18] In the demonstration Model the oscilloscope shown in Figure 12 was a Bradley (model unknown). The 547 Sig Tp Progress Report for April 1968, reported: *Bradley Type 149 CRO replaced by Tektronix Type 422 CRO. New CRO is big improvement*.

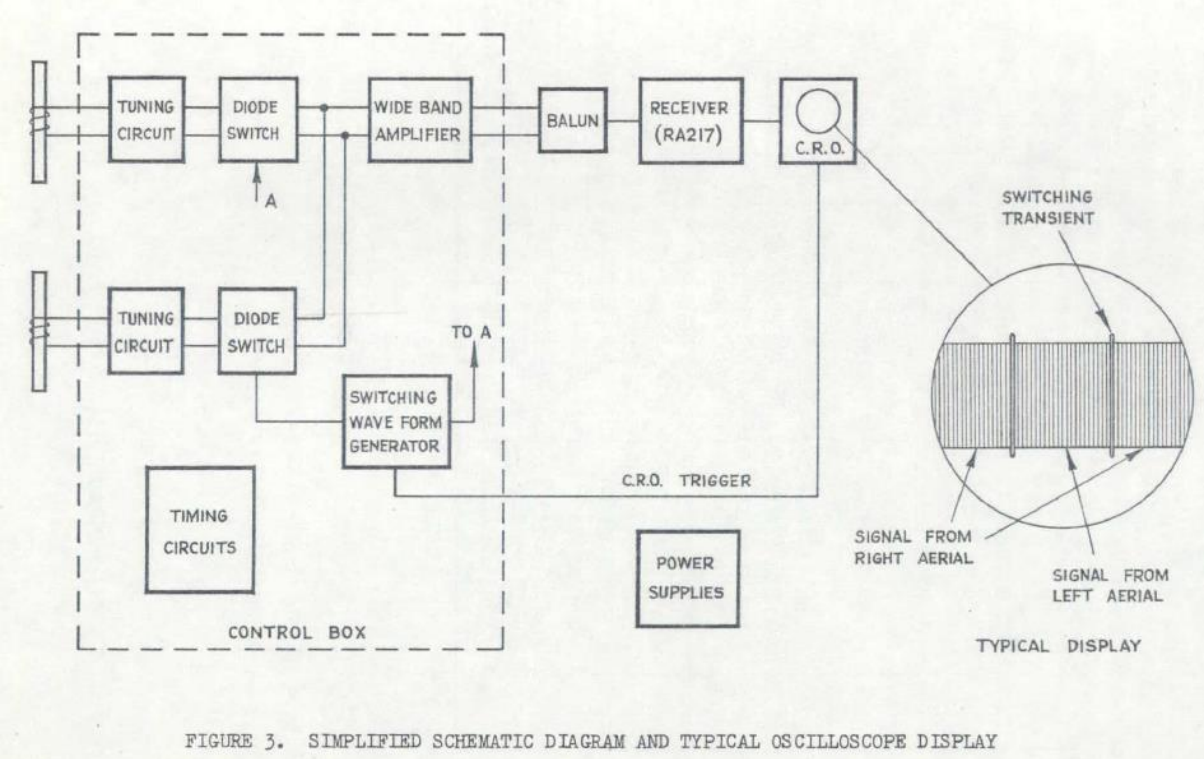


Figure 15: Simplified Schematic[19]

- **Goniometer.** The goniometer is affixed to the top of the rotatable antenna array. When the graticule is aligned on the 0/360 degree mark, this indicated that the centre line of the antenna array is aligned with the centre line of the aircraft. Any bearing to DF target is relative to the aircraft centre line, and therefore to the aircraft heading.
- **Rustrak Chart Recorder.[20]** Displays a graphic image, on continuous chart paper, of the relative RF amplitude from the HF long wire antenna. In theory, at the point of maximum amplitude, the aircraft centre line is at right angles to the DF target transmitter.
- **Akai XV Tape Deck.** Primarily to record the intercepted message traffic.
- **AN/PRC-77 VHF Transceiver.** For air to ground communication with ARDF control. In most cases it was paired with a TSEC/KY-38 voice encryption unit to provide secure communications with the Troop.

[19] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F91

[20] Ibid, F94, and NAA D4884, CPD(T) 145: *Included in the equipment is a 'back-up; field strength type direction finder. This makes use of a separate whip aerial, a receiver and Rustrak Recorder. The strength of a signal is continuously recorded and the maximum field strength is obtained at the closes approach to a transmitter i.e. when bearing of transmitter is at right angles to the track. This provides a useful check on results obtained from the main system.*

DF Procedure

The procedure for obtaining a fix was similar to that used by the old system:

- **Antenna**. After take-off the operator would lower the antenna pod and conduct a general search to find new targets.
- **Aircraft Location.** The pilot would be continually relating map to ground to identify features that could easily be located on a map.
- **Target Acquisition.** When the operator detected a target on his receivers he would ask the pilot to start a run/track and if known, on a certain heading.
- **Start point.** The pilot would immediately stand the aircraft on a wing hopefully pointing the wing at a reference point then flare out over the start point and signify "time on" to the operator. The operator would immediately start the time clock.
- **Signal Display.** When a signal was received it was visually displayed on the Tektronix Cro. The following photographs show the CRO without a signal and then a signal[21].

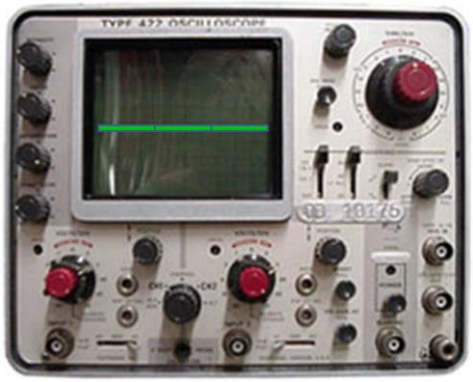


Figure 16: Tektronix Cro with no signal

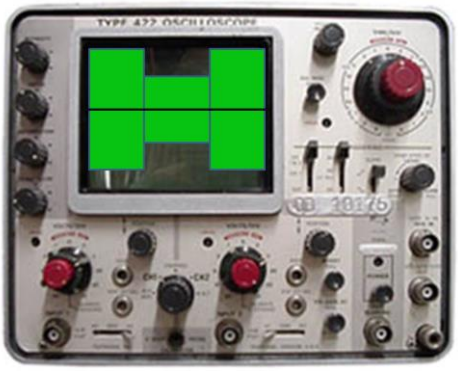


Figure 17: Tektronix Cro with signal

- **Obtaining LOBs.** After the pilot signified start, the operator rotated the antenna until the displayed signal legs on the CRO display were balanced [level]. This indicated that the antenna was pointed directly at the transmitter relative to the

[21] Example signal graphics inserted by Bob Hartley

heading of the aircraft. When level, the operator would record the elapsed time from the clock and the bearing from the scale on the goniometer.

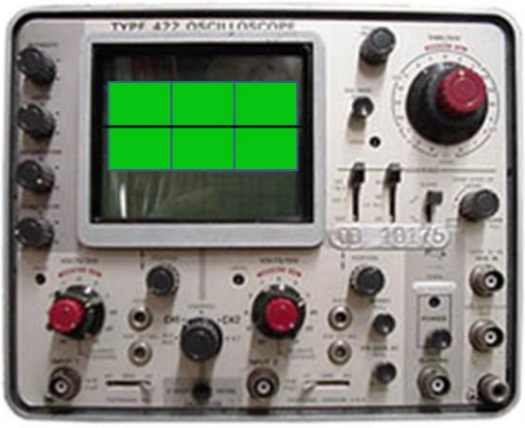


Figure 18: Antenna lined up for LOB

- **Track and Speed.** The pilot would fly the aircraft at a constant altitude and speed. The ideal speed was 110 knots.
- **Additional LOBs.** The taking of LOBs would continue until the target transmission ceased or the operator considered that sufficient LOBs had been taken to determine an accurate fix.
- **Stop.** When the operator believed that he had sufficient LOBs for a fix, or that the target ceased transmission, he would ask the pilot to stop the run.
- **Stop Point.** The pilot would then attempt to find an end point under the aircraft that he can relate to the map. When an end point is identified and reached the pilot would tell the operator "stop", and the operator would stop the time clock. The pilot would inform the operator the start and finish grid references and the heading of the aircraft.
- **Additional Tracks.** If time permitted the pilot would try to fly other tracks at a different heading around the target.

Operator's Knee Pad

The ARDF Operator had a 'Pilots Kneepad' secured to his leg that held the Operators Log where all the details of a 'run' were inserted.

Figure 19: Operator's Knee Pad

The following graphic shows an example of a raw Operators Log.

Date	*010469*	Ident	*B4013*
Freq	*5480*	Callsign	*ABC DE DEF*
Start GR	*123456*	End GR	*654321*
Heading	*020*	MV *003*	End Time *133*
Time	Bearing	Plot	
10	70		
16	78		
23	84		
30	95		
40	105		
53	130		
65	150		
95	185		

Figure 20: ARDF Operators log example

Plotting

Normally the plotting of the fixes would be undertaken by the operator when he returned to the Troop. In an emergency i.e. suspected significant movement of the transmitter to the known location of Australian and Allied forces, the log information would be passed back to the troop by the secure radio for immediate plotting.

When plotting a fix the operator would use a CR-3 Air Navigation Computer (slide rule) to calculate the correct air speed, correlation between air speed and time along the track for plotting LOBS.

Figure 21: CR-3 Air navigation slide rule

The following graphic gives a very simple example of an ARDF track that would be drawn on to the plotting board (*less aircraft icon*).

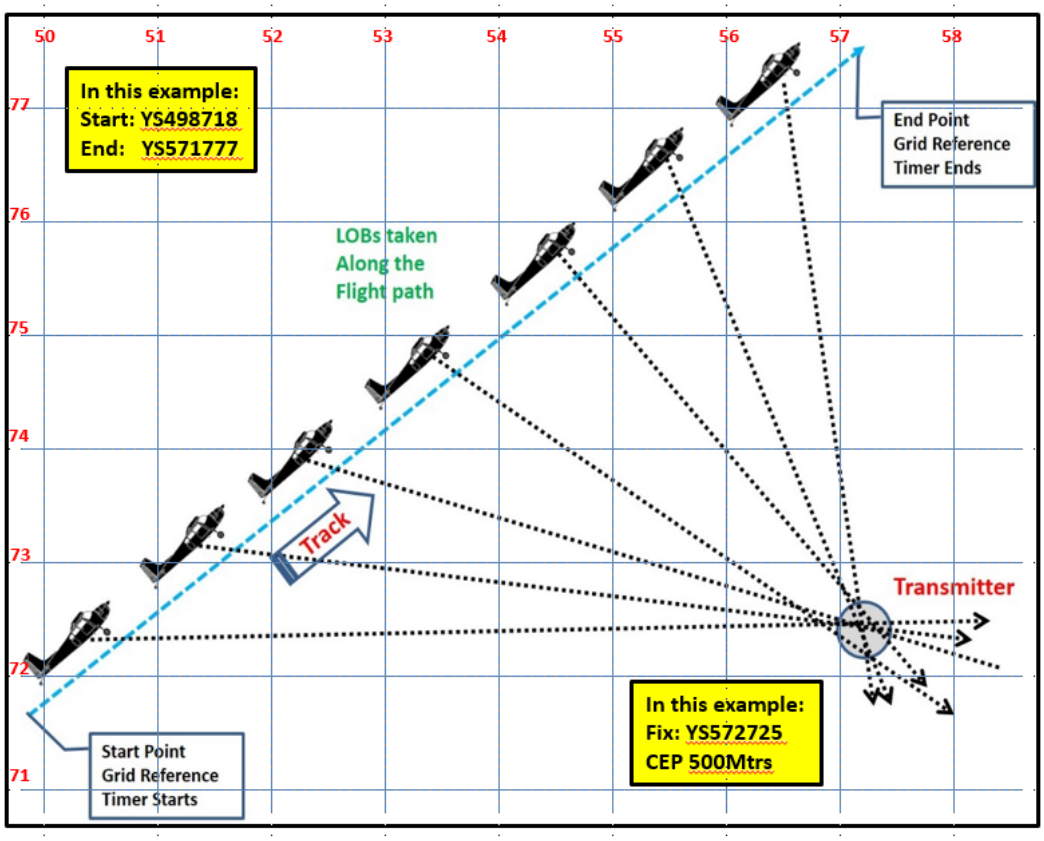


Figure 22: ARDF Plot

Note:

The more intersections at the central point, the better accuracy

Accuracy

The circular error of probability (CEP)[22] obtained by this experimental system was quite exceptional. The Australian system was much more accurate that the US systems and if the aircraft had been calibrated correctly, flying conditions perfect, start and finish point accurate, a CEP of 50 -100 meters was achievable. It was rare to have all these factors happening, so the normal CEPs would range from 500 to 1500 meters.

Aircraft in Flight

The following photograph shows the ARDF aircraft in flight. Note the additional antennas on top of the fuselage that were used for general search, the Rustrak Recorder, and operator to ground communications. The DF antenna pod is shown under the fuselage in the stowed position.

Figure 23: Cessna ARDF aircraft in Flight. Antenna Pod in stowed condition

Change or Servicing of Aircraft

After any maintenance, service, change of aircraft or ARDF equipment taken out for maintenance, it was necessary for the aircraft to be re-calibrated to maintain the accuracy of the ARDF system. The following actions were required:

- **Aircraft Compass**. To ensure accuracy of the aircraft compass, the aircraft had to have a compass swing[23] at regular intervals. This was critical after any maintenance on the aircraft which involved removal/replacement of any component of engine, airframe, avionics or external ordnance.

[22] An intuitive measure of a system's precision. In DF terms it is the approximate average distance between a centre point and the intersecting lines (LOBs).

[23] **Compass Swing**. In basic terms this involves checking the on-board aircraft compass for accuracy and where necessary producing a correction chart. All of the normal operating equipment must remain in the aircraft and the compass swing action is carried out by aircraft maintenance staff. This is a lengthy process and could only be done when the aircraft was not on sorties.

- **ARDF Correction Chart.** Each aircraft had its own electronic characteristics that affected the accuracy of the arrival of the received target signal. Whenever there was a major service or change of component of the aircraft, installation or replacement of ARDF equipment, an ARDF Correction Chart had to be produced. This chart could only be achieved by many flights around a known target transmitter. A small HF beacon was installed in the Troop and firm start and finish points for at least three tracks around the beacon were noted around Nui Dat. The aircraft would have to fly many legs around the beacon and the operator would be taking LOBs as per normal along each track. This procedure would continue at least two times for each frequency band. On the ground all the tracks would be plotted and from the resultant information, a correction chart for all frequency bands could be obtained.[24] This was a lengthy process so, any change to the aircraft structure was kept to a minimum.[25]
- **ARDF Antenna Array**. The ARDF antenna array had to be checked regularly for accurate alignment with the aircraft centre line.

Missions

Normally, a minimum of two sorties each of at least 2½ hours duration were flown each day, seven days per week. Sorties were even flown during periods of cease fire e.g. Christmas Day, Easter, and TET. If an aircraft developed a fault the equipment was immediately changed to another aircraft.

Night missions were also attempted but they were mainly unsuccessful due to the pilot not being able to get accurate start and finish points. On occasions that it was imperative that night missions were flown and the aircraft was operating close to their position, arrangements were made with fire support bases to fire flares on demand to provide a more accurate start/finish point.

It has been mentioned previously that to obtain the best ARDF results the aircraft was required to fly on a constant heading, altitude, maintain a constant speed of 110 knots, and at between two to three thousand feet (the optimum 2,000) above ground level. This altitude normally placed the aircraft beyond small arms fire. However, the terrain in the province contained many large hills/mountains (Nui Dinhs and Long Hais) and when the aircraft was flying above, around and through them, the aircraft came well within small arms fire range and at times did receive ground fire.

[24] **Correction Chart**. The correction chart would allow the operator to include give any correction necessary to a signal arriving on a particular frequency. i.e 5400 khz may have a correction of -2 deg, 7200 khz +3 deg.

[25] Steve Hart email to Bob Hartley 29 Nov 2015 .Steve Hart. [In late 1968], one of the first tasks I had to undertake was conduct trials of our ARDF kit in acft with retractable undercarriages to determine the impact on the existing correction charts. To do this, I had to arrange with 146 Avn Coy for the loan of a "suitably modified" U6 Seminole to be sent to Nui Dat on an as available basis. Availability basis, with heavy operational commitments, meant that these acft invariably came down just for the day and the trial extended over a protracted period, but the end results indicated that the correction chart figures virtually halved without an undercarriage. The potential use of ARDF was one of the factors which led to the design of that twin engine Nomad acft for army aviation.

ARDF Missions Could be Dangerous - Aircraft Mishap

On August 24, 1968, Aircraft A98-043 was active approximately thirty kilometres north of the 1ATF Base. The days sortie had been completed and the aircraft was descending on its way back to Nui Dat. Suddenly the aircraft started vibrating and losing power. The pilot sent out an emergency signal and did a forced landing in a paddy field. The passenger and ARDF operator escaped from the aircraft without injury and were soon rescued by a passing allied patrol and then picked up by a US Army helicopter that was in the area.

Later in the day the damaged aircraft and equipment was recovered and transported back to Nui Dat. Inspection of the aircraft revealed that the aircraft had been hit by small arms fire causing damage to the propeller housing.

The equipment survived the landing and was repositioned into another aircraft. The aircraft was a write-off.

Note:

At times, other ARDF aircraft received ground fire with little damage and all aircraft returned safely

Figure 24: Pilot (Lt Tizzard) and Operator (Dick Schafer) with the recovered Cessna

Figure 25: Recovered aircraft

Figure 26: ARDF aircraft having an engine check

Figure 27: Bob Hartley getting ready to fly on a mission[26]

American Visitors

When the Australian ARDF system and results became known to the Americans, many senior officers and US ARDF Operators visited the Troop to see how the system worked. They were all amazed that such a small aircraft and equipment could produce such excellent results. A few visitors were given flights in the aircraft but this was not encouraged as the increased weight in the aircraft decreased flight times.

US Army U-8 Aircraft Trials

In January 1968, the Officer Commanding of 547 Sig Tp, began having discussions with US Army authorities regarding fitting the Australian ARDF System in the U-8 Aircraft:

Extract from The 547 Sig Tp Progress Report for 1-31 Jan 68[27].

> *BRAVO. (1) CONFERENCE WITH COL SINPKIN [sic] AT 161 RECCE FLIGHT AND DISCUSSED PROPOSED NEW AIRCRAFT. HE STATES THAT J2 MACV AGREE OUR SYSTEM OBTAINS FIXES MORE QUICKLY THAN US SYSTEM BUT THEY REQUIRE MORE PROOF OF ACCURACY OF EQUIPMENT. I HAVE PREVIOUSLY REQUESTEDTHAT US ARDF AIRCRAFT FLY SAME MISSIONS AS OUR AIRCRAFT AGAINST BEACON FROM KNOWN LOCATIONS.*
>
> *THAT TWO US ARMY OPERATORS BE DETACHED TO WORK OUR SYSTEM AND REPORT BACK TO 509 RR GROUP.*
>
> *2. [Redacted] AND 509 RR GROUP AGREE THAT THIS WOULD BE IDEAL BUT NOTHING HAS BEEN DONE. COL SIMPKIN AND SELF WERE TO VISIT [Redacted] ON 31 JAN BUT DUE TO*

[26] When this photograph was taken the operators were not issued with flight safety equipment. Some operators were able to 'borrow' Nomex flight suits from the friendly US ARDF teams. In approx 1971 flight suits were issued.

[27] Documents received from ASD December 2015.

TET VC OFFENSIVE IN SAIGON BOTH MEMBERS CONFINED TO BOQS[28]*. CONFERRED WITH SO SIGS 1 FEB AND CONFERENCE CANCELLED AS COL SIMPKIN IS TO FLY OUT OF SAIGON ON FIRST AVAILABLE AIRCRAFT.*

Extract from 547 Sig Tp Progress Report for 1-30 Jun 68[29]:

E. PROGRESS ON US AC LOAN. . HAVE AGREED TO FLY OUR AC TO TAN SON NHUT FOR EXAMINATION BY USARV AVIATION SAFETY ENGRS AS AT DATE YET TO BE NOTIFIED. ARDF FRAME AND ACCESSORIES ARRIVED FROM WRE.

Extract from 547 Sig Tp Progress Report for 1-31 Aug 68[30]:

E. RESERVE ARDF EQPT WILL BE TAKEN TO SAIGON 2 SEP 68 BUT STILL NO WORD ON US AIRCRAFT AVAILABILITY.

Extract from 547 Sig Tp Progress Report for 1-30 Sep 68[31]:

HOPE TO COMMENCE AUST ARDF TRIALS IN US U-8D 3 OCT. SIG TALBERT WILL BE TRIALS OPERATOR

Paul Talbert wrote[32]:

Near the end of 68 I did trials with our equipment with the Americans, having the equipment fitted in what I believed to be a Beechcraft 'Queen Air' but I may be wrong about the type of aircraft. We got a lot of spurious readings due to the hull of that type of aircraft and at the end I don't think it was very successful.

Warning Order for Cessna Replacement

The 547 Sig Tp Monthly Progress Report or 1 – 31 Oct 68 contained the following[33]:

ECHO. YOU MAY BE INTERESTED TO KNOW THAT CESSNAS ARE TO BE WITHDRAWN FROM THEATRE AND REPLACED BY SIOUX HELICOPTERS UNTIL PILATUS PORTERS ENTER THEATRE APPROX MARCH 1969. I HAVE IMPRESSED UPON COMD AFV AND COMD 1ATF (AND OBTAINED THEIR SUPPORT) FOR THE RETENTION OF 2 CESSNAS UNTIL PORTERS ARRIVE. THIS WILL BE SUBJECT OF LATER SIG WHEN MORE DETAILS AVAIL, BUT MATTER RAISED AS A WNG ORDER FOR 2 POINTS. ONE. CONTRACT ENGINEERED MODELS SHOULD BE HASTENED IF AT ALL POSSIBLE AND TWO, EQPTS SHOULD BE CALIBRATED IN PORTERS IN AUST UNDER WRE SUPERVISION. FROM BITTER EXPERIENCE WITH TRIALS IN U8D, THERE ARE TOO MANY PROBLEMS INVOLVED WITH CALIBRATING EQPT/AIRCRAFT IN THEATRE, AND WITH THE LARGER WING SPAN OF PORTER, WOULD EXPECT SOME DIFFICULTY NEAR THE HIGH FREQUENCIES, REQUIRING SCIENTIFIC GUIDANCE. ONE POINT MUST STRESS NOW. INSTALLATION OF ARDF EQPT IN AIRFRAME WILL MINIMISE CALIBRATION DIFFICULTIES IF ANTENNA SHAFT SITUATED ON THE EXACT CENTRE AXIS OF FUSELAGE. IF WE ARE GOING TO CUT A HOLE IN THE AIRCRAFT, LET IT BE WHERE IT IS TO OUR BENEFIT. COMPLETE EXPLANATION WILL FOLLOW IN HARD COPY REPORT OF U-8 TRIALS.

[28] Bachelor Officers Quarters.

[29] Documents received from ASD December 2015.

[30] Ibid.

[31] Ibid.

[32] Email to Bob Hartley.

[33] Documents received from ASD December 2015.

Project Thorough

Background

About 1966, the Army declared the Cessna 180 obsolescent and sought a replacement fixed wing aircraft. The Pilatus Turbo-Porter (PC-6/B2-H2 Australian Military Specification) [34] became the preferred replacement for the Cessna 180.

The Porter was first introduced into service from 1968 and the Army eventually procured 19 Porter aircraft. The first Porter was delivered to the 1st Aviation Regiment at RAAF Base Amberley Qld, on 25 September 1968 after being flown to Australia from Stans in Switzerland.

Figure 28:Pilatus Porter[35]

The Cessna 180D aircraft being flown by 161 Recce Flt in Vietnam were scheduled to be replaced by the Pilatus Porter P-6 in late 1969.

As a prelude to the delivery of the Porter, WRE was tasked to develop an engineered version of the ARDF System for the Cessna and Porter aircraft based on the experimental model being used in South Vietnam. This development was titled Project Thorough[36].

The initial experimental models built for the Cessna aircraft were produced by the Chemistry and Physics Division of WRE in 1967, and had been found to operate satisfactorily.

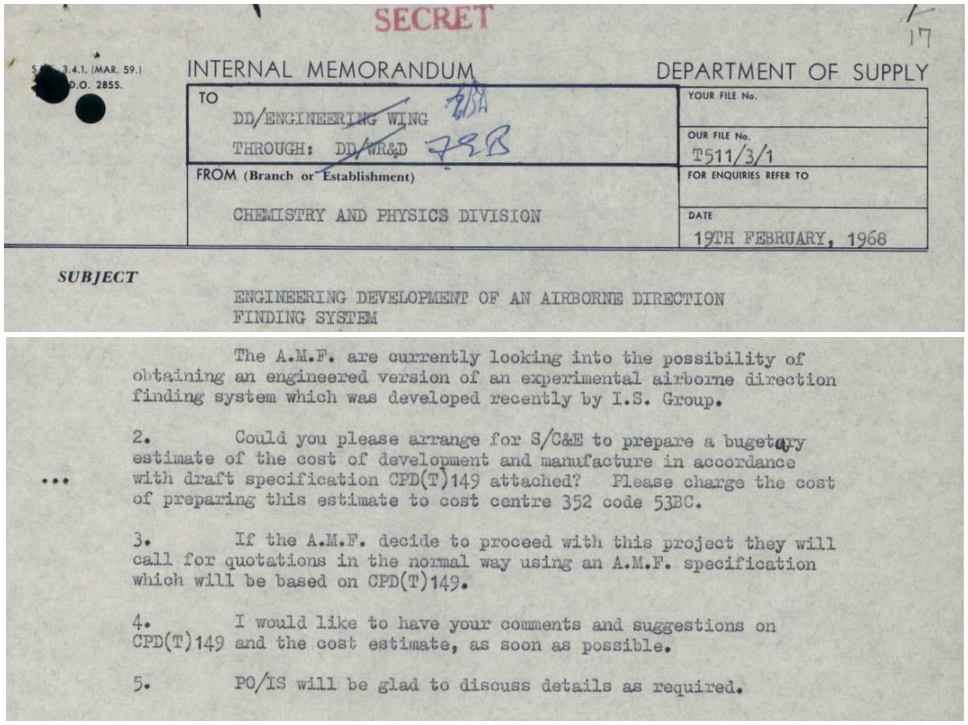
[34] https://en.wikipedia.org/wiki/Pilatus_PC-6_Porter. The **Pilatus PC-6 Porter** is a single-engined Short Take-Off and Landing (STOL) utility aircraft designed by Pilatus Aircraft of Switzerland. First flown in 1959. The PC-6 is noted for its *Short Take-off and Landing* (STOL) performance on almost any type of terrain - it can take off within a distance of 640 feet (195 m) and land within a distance of 427 feet (130 m) while carrying a payload of 2,646 lbs (1,200 kg).

[35] http://www.pilatus-enthusiasts.com.au/Aust.Army.html

[36] The original Project name for the Australian system was Project High Divine.

Initial Request for a New Model

On 19 February 1968, the following Internal Memorandum was passed from the Engineering Wing to the Chemistry and Physics Division at WRE[37]:



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S[illegible] 3.4.1. (MAR. 59.)
D.O. 2855.

INTERNAL MEMORANDUM — DEPARTMENT OF SUPPLY

TO
DD/ENGINEERING WING
THROUGH: DD/WR&D

YOUR FILE No.

OUR FILE No.
T511/3/1

FROM (Branch or Establishment)
CHEMISTRY AND PHYSICS DIVISION

FOR ENQUIRIES REFER TO

DATE
19TH FEBRUARY, 1968

SUBJECT
ENGINEERING DEVELOPMENT OF AN AIRBORNE DIRECTION FINDING SYSTEM

The A.M.F. are currently looking into the possibility of obtaining an engineered version of an experimental airborne direction finding system which was developed recently by I.S. Group.

2. Could you please arrange for S/C&E to prepare a bugetary estimate of the cost of development and manufacture in accordance with draft specification CPD(T)149 attached? Please charge the cost of preparing this estimate to cost centre 352 code 53BC.

3. If the A.M.F. decide to proceed with this project they will call for quotations in the normal way using an A.M.F. specification which will be based on CPD(T)149.

4. I would like to have your comments and suggestions on CPD(T)149 and the cost estimate, as soon as possible.

5. PO/IS will be glad to discuss details as required.

Figure 29: Engineering and Development of an Airborne Direction Finding System

[Copy]

The A.M.F. are currently looking into the possibility of obtaining an engineered version of an experimental airborne direction finding system which was developed recently by I.S. Group.

2. Could you please arrange for S/C&E to prepare a budgetary estimate of the cost of development and manufacture in accordance with draft specification CPD(T) 149 attached?. Please charge the cost of preparing this estimate to cost centre 352 code 53BC.

3. If the A.M.F. decide to proceed with this project they will call for quotations in the normal way using an A.M.F. Specification which will be based on CPD(T) 149.

4. I would like to have your comments and suggestions on CPD(T) 149 and the cost estimate, as soon as possible.

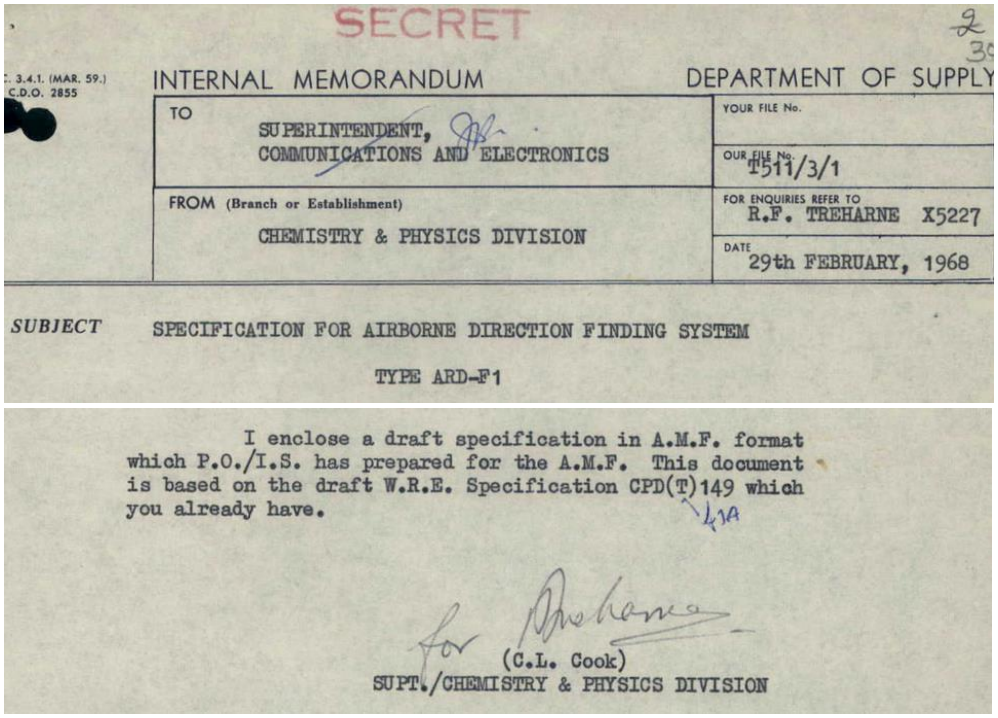
5. PO/IS will be glad to discuss details as required.

Draft Specifications

On 29 February 1968, the Chemistry and Physics Division sent the following Memorandum to the Chemistry and Physics Division[38]:

[37] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F17

[38] Ibid F30. Note title ARD-F1 [first time seen].



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C.D.O. 2855

INTERNAL MEMORANDUM — DEPARTMENT OF SUPPLY

TO: SUPERINTENDENT, COMMUNICATIONS AND ELECTRONICS

YOUR FILE No.

OUR FILE No. T511/3/1

FROM (Branch or Establishment): CHEMISTRY & PHYSICS DIVISION

FOR ENQUIRIES REFER TO R.F. TREHARNE X5227

DATE 29th FEBRUARY, 1968

SUBJECT: SPECIFICATION FOR AIRBORNE DIRECTION FINDING SYSTEM
TYPE ARD-F1

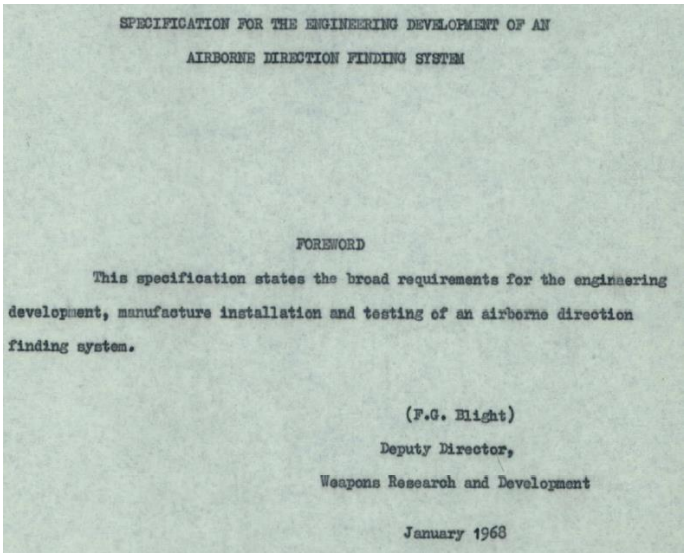
I enclose a draft specification in A.M.F. format which P.O./I.S. has prepared for the A.M.F. This document is based on the draft W.R.E. Specification CPD(T)149 which you already have.

for

(C.L. Cook)
SUPT./CHEMISTRY & PHYSICS DIVISION

Figure 30: Specifications

Extracts from the Draft Specifications CPD (T) 149 dated January 1968 and 19 February follow[39]:



SPECIFICATION FOR THE ENGINEERING DEVELOPMENT OF AN AIRBORNE DIRECTION FINDING SYSTEM

FOREWORD

This specification states the broad requirements for the engineering development, manufacture installation and testing of an airborne direction finding system.

(F.G. Blight)
Deputy Director,
Weapons Research and Development

January 1968

Figure 31: Specification cover sheet

[Copy]

FORWARD

This specification states the broad requirements for the engineering development, manufacture installation and testing of an airborne direction finding system.

[39] Ibid, F16, F29.

Figure 32: Specification Introduction

[Extract]

1. INTRODUCTION

This specification states the broad requirements for the engineering Development and manufacture of an h.f. airborne radio direction finding system for installation in light aircraft used by the Australian military Forces.

The system is based on experimental equipment developed by the Ionospheric Studies Group of the Chemistry and Physics Division. It is currently in operational use in Vietnam in two forms, viz., model A which employs mechanical tuning of the aerial and model B which employs electronic tuning of the aerial. The engineered version is to be based on Model B techniques. A Technical Note (1) describing these experimental models will be made available for the guidance of the Contractor.

.

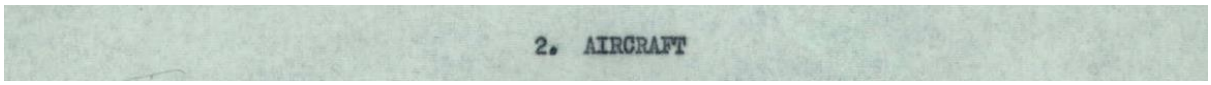


Figure 33: Specifications – Aircraft

[Extract]

2. AIRCRAFT

The equipment is to be suitable for rapid installation and removal from a Cessna 180 aircraft of the A.M.F. with a minimum of modifications to the aircraft. Additionally, the equipment shall be suitable for installation in such other aircraft as are specified at the time of commencing the contract.

Figure 34: Specifications –Requirements #1

[Extract]

4. REQUIREMENTS
4.1 General

This specification states the broad requirements for the engineering development, and manufacture of an h.f. airborne radio direction finding system for installation in light aircraft used by the Australian military Forces.

The system is based on experimental equipment developed by the Ionospheric Studies Group of the Chemistry and Physics Division, Weapons Research Establishment. It is currently in operational use in Vietnam in two forms, viz., model A which employs mechanical tuning of the aerial and model B which employs electronic tuning of the aerial. The engineered version is to be based on Model B techniques. A Technical Note describing these experimental models will be made available for the guidance of the Contractor. (See para. 2 above).

4.2 Aircraft
The equipment is to be suitable for rapid installation and removal from a Cessna 180 aircraft of the A.M.F. with a minimum of modifications to the aircraft. Additionally, the equipment shall be suitable for installation in such other aircraft as are specified at the time of commencing the contract.

Figure 35: Specifications –Quantity

[Extract]

4.4 Quantity
The engineering design whall be based on the assumption that 5 complete units are required.

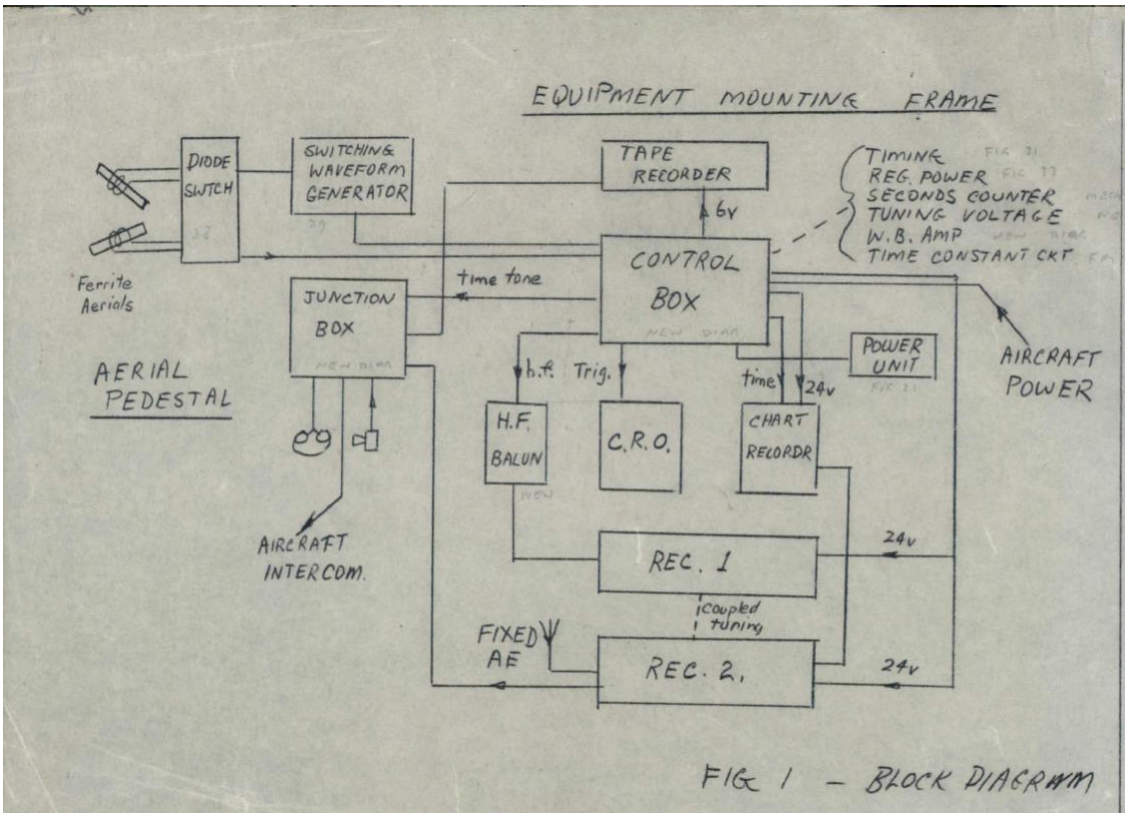
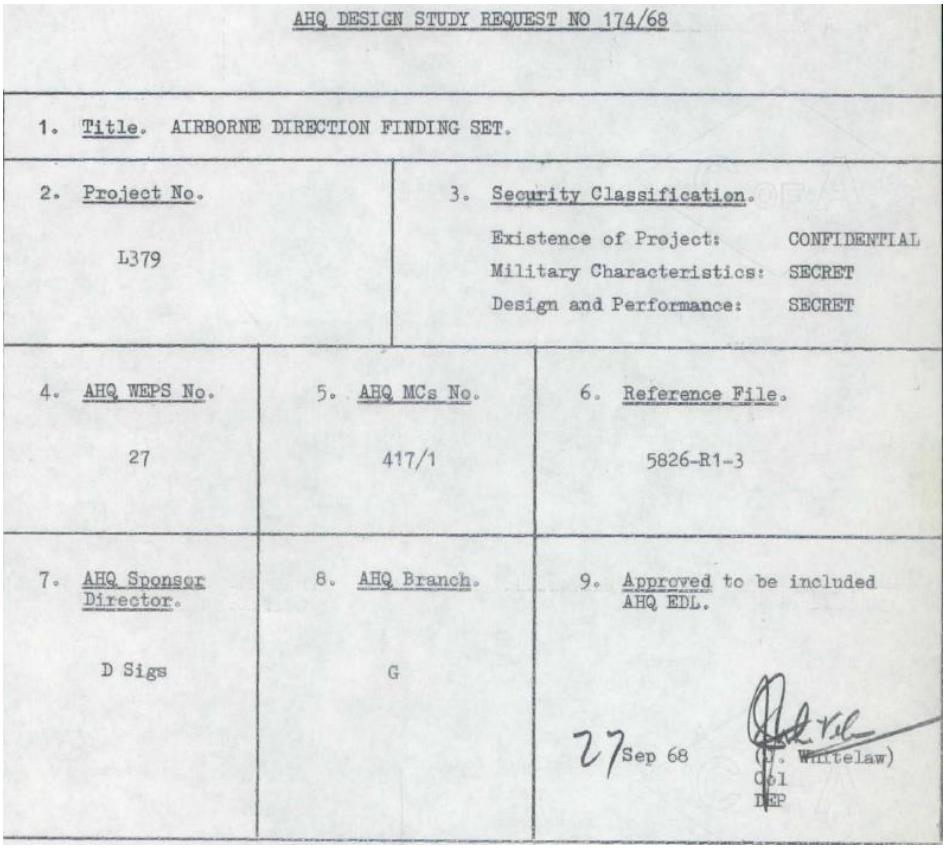


Figure 36: Block Diagram

On 27 September 1968, Army HQ issued a Design Study Request[40]:



AHQ DESIGN STUDY REQUEST NO 174/68

1. Title. AIRBORNE DIRECTION FINDING SET.

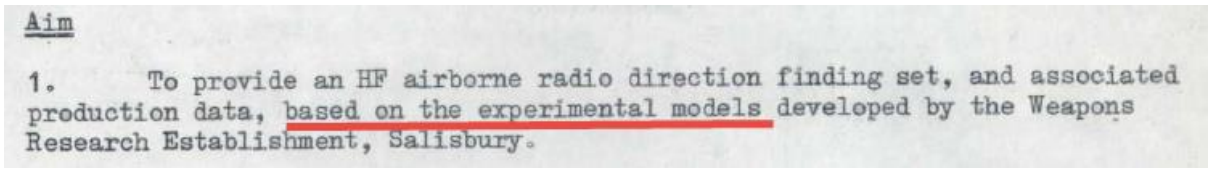
2. Project No.	3. Security Classification.
L379	Existence of Project: CONFIDENTIAL Military Characteristics: SECRET Design and Performance: SECRET

4. AHQ WEPS No.	5. AHQ MCs No.	6. Reference File.
27	417/1	5826-R1-3

7. AHQ Sponsor Director.	8. AHQ Branch.	9. Approved to be included AHQ EDL.
D Sigs	G	27 Sep 68 (W. Whitelaw) CGS1 DEP

Figure 37: Design Study Request

Extracts from the Design Study Request[41] [*Essential points highlighted by Authors*]



Aim

1. To provide an HF airborne radio direction finding set, and associated production data, based on the experimental models developed by the Weapons Research Establishment, Salisbury.

Figure 38: Design Study Request – Aim

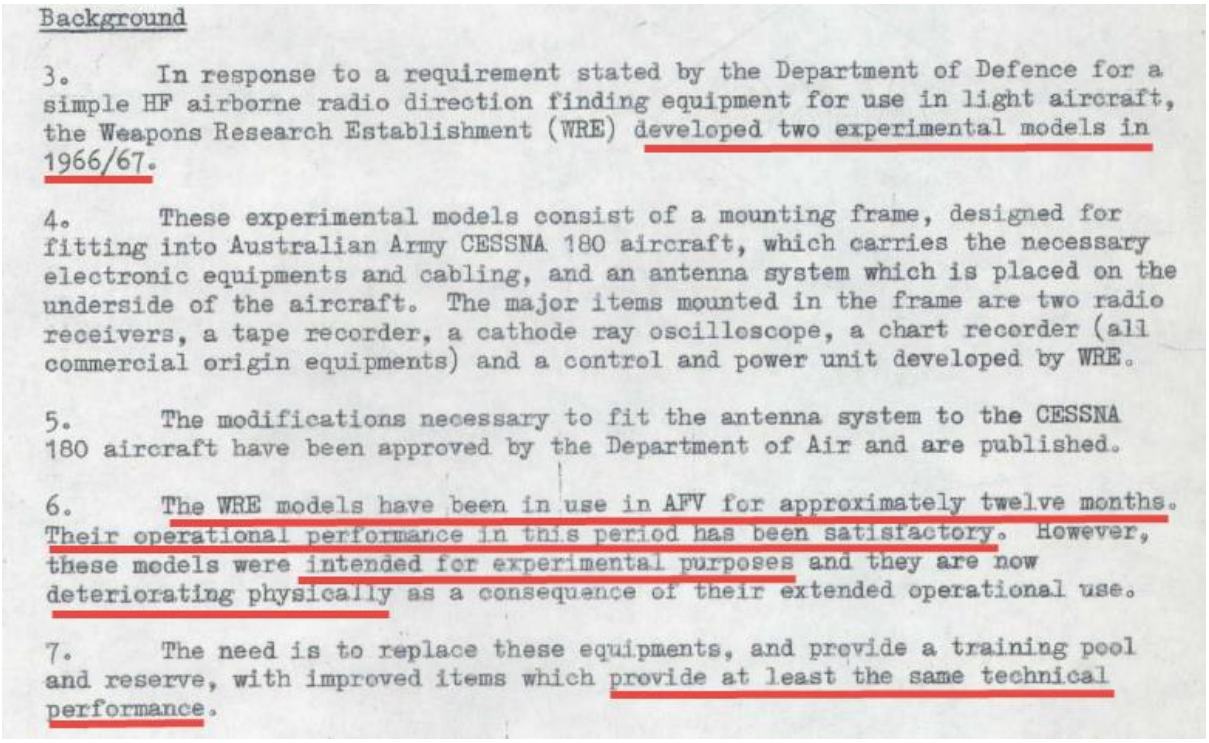
[Copy]

Aim

1. To provide an HF airborne Radio direction finding set, and associated production data. Based on the experimental models developed by the Weapons Research Establishment, Salisbury.

[40] Ibid, F110.

[41] Ibid, F105 -109.



Background

3. In response to a requirement stated by the Department of Defence for a simple HF airborne radio direction finding equipment for use in light aircraft, the Weapons Research Establishment (WRE) developed two experimental models in 1966/67.

4. These experimental models consist of a mounting frame, designed for fitting into Australian Army CESSNA 180 aircraft, which carries the necessary electronic equipments and cabling, and an antenna system which is placed on the underside of the aircraft. The major items mounted in the frame are two radio receivers, a tape recorder, a cathode ray oscilloscope, a chart recorder (all commercial origin equipments) and a control and power unit developed by WRE.

5. The modifications necessary to fit the antenna system to the CESSNA 180 aircraft have been approved by the Department of Air and are published.

6. The WRE models have been in use in AFV for approximately twelve months. Their operational performance in this period has been satisfactory. However, these models were intended for experimental purposes and they are now deteriorating physically as a consequence of their extended operational use.

7. The need is to replace these equipments, and provide a training pool and reserve, with improved items which provide at least the same technical performance.

Figure 39: Design Study Request – Background

[Copy]

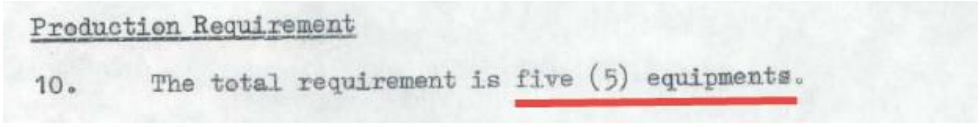
Background
3. In response to a requirement stated by the Department of Defence for a simple HF airborne radio direction finding equipment for use in light aircraft, the Weapons Research Establishment (WRE) developed two experimental models in 1966/67.

4. These experimental models consist of a mounting frame, designed for fitting into Australian Army Cessna 180 Aircraft, which carries the necessary electronic equipments and cabling, and an antenna system which is placed on the underside of the aircraft. The major items mounted in the frame are two radio receivers, a tape recorder, a cathode ray oscilloscope, a chart recorder (all commercial origin equipments) and a control and power unit developed by WRE.

5. The modifications necessary to fit the antenna system to the CESSNA 180 aircraft have been approved by the Department of Air and are published.

6. The WRE Models have been in use in AFV for approximately twelve months. their operational performance in this period has been satisfactory. However, these models were intended for experimental purposes and they are now deteriorating physically as a consequence of their extended operational use.

7. The need is to replace these equipments, and provide a training pool and reserve, with improved items which provide at lleast the same technical performance.



Production Requirement

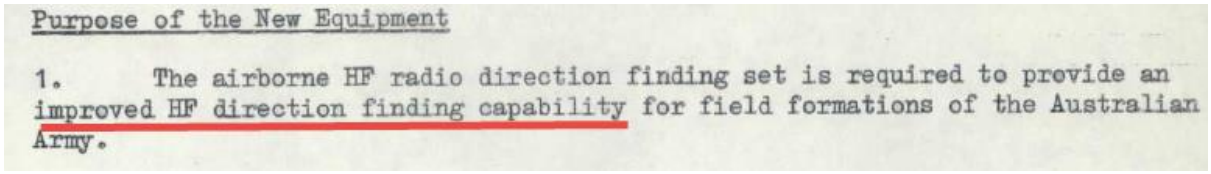
10. The total requirement is five (5) equipments.

Figure 40: Design Study Request - Production Requirement

[Copy]

Production Requirement

10. The total requirement is five (5) equipments.



Purpose of the New Equipment

1. The airborne HF radio direction finding set is required to provide an improved HF direction finding capability for field formations of the Australian Army.

Figure 41: Design Study Request - Purpose of New and Existing Equipment

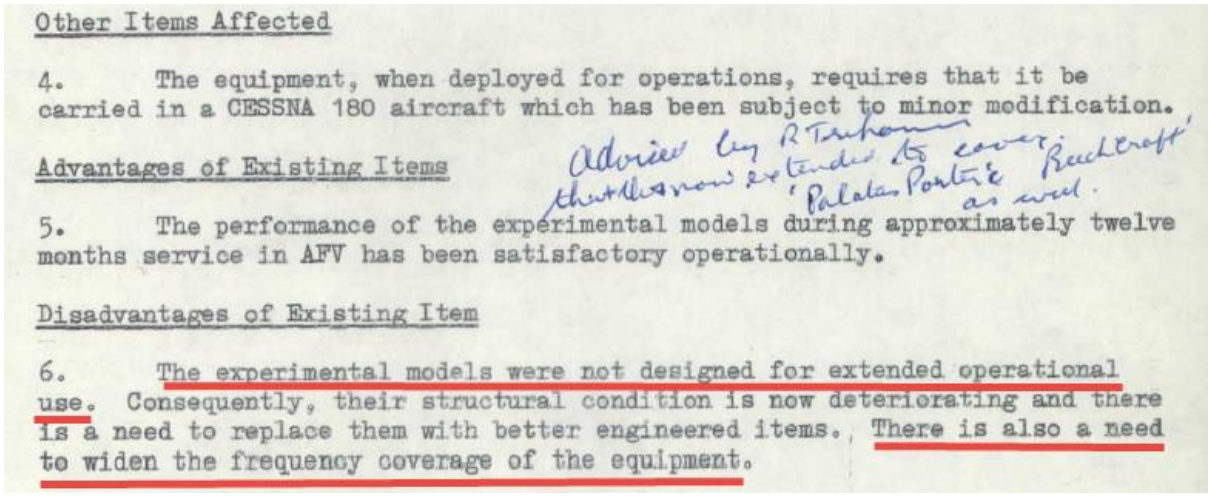
[Extract]

Purpose of New Equipment

1. The airborne HF radio direction finding set is required to provide an improved HF direction finding capability for field formations of the Australian Army.

Existing Equipment

2. Two (2) experimental radio direction finding equipments made by the Weapons Research Establishment, are in use in AFV.



Other Items Affected

4. The equipment, when deployed for operations, requires that it be carried in a CESSNA 180 aircraft which has been subject to minor modification.

Advantages of Existing Items

Advised by R Tarbotton that this was now extended to cover Falcon, Porter & Beechcraft as well.

5. The performance of the experimental models during approximately twelve months service in AFV has been satisfactory operationally.

Disadvantages of Existing Item

6. The experimental models were not designed for extended operational use. Consequently, their structural condition is now deteriorating and there is a need to replace them with better engineered items. There is also a need to widen the frequency coverage of the equipment.

Figure 42: Design Study Request - Advantages and Disadvantages

[Copy and extract]

Other Items Affected

4. The equipment, when deployed for operations, requires that it be Carried in a CESSNA 180 aircraft which has been subject to minor modification.

Advantages of Existing Items

5. The performance of the experimental models during approximately twelve months service in AFV has been satisfactory operationally
Disadvantages of Existing Items

6. The experimental models were not designed for extended operational use. Consequently their structural condition is now deteriorating and there is a need to replace them with better engineered items. There is also a need

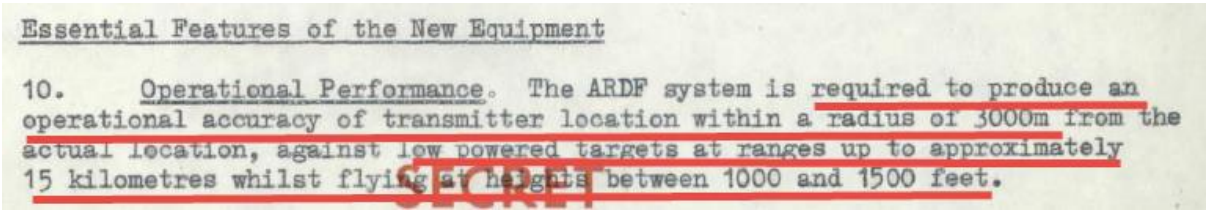
to widen the frequency coverage of the equipment.

General Features of the New Equipment

7. The equipment reqqired is to be based on the "B" experimental model produced by WRE (See para 3).

8. The direction finding capability of the experimental models is based on a process which relates a known flight direction, a known flight path, the timings of specified events and the taking of readings when the outputs of two receiver channels allied to a directional aerial array are equal, in order that the true azimuth to a radio transmitter can be determined.

9. The design of the experimental model is based on a concept which amalgamates the facilities of commercial origin equipments (the receivers, the tape recorder, CRO and chart recorder) with specially designed items (the antenna and control units) to provide and record the desired information.


Essential Features of the New Equipment

10. Operational Performance. The ARDF system is required to produce an operational accuracy of transmitter location within a radius of 3000m from the actual location, against low powered targets at ranges up to approximately 15 kilometres whilst flying at heights between 1000 and 1500 feet.

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Figure 43: Design Study Request - Operational Performance[42]

[Copy and extract]

Essential Features of the New Equipment

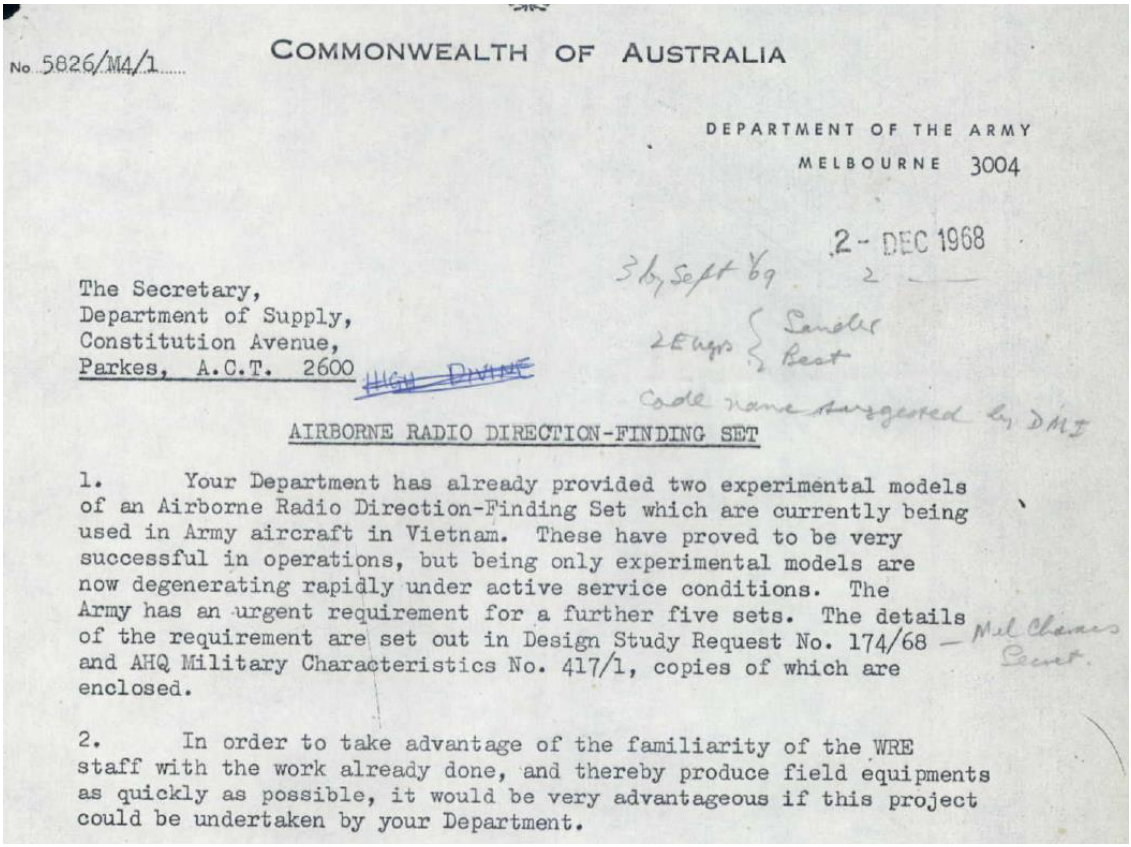
10. Operational Performance. The ARDF system is required to produce an Operational accuracy of transmitter location within a radius of 3000m from the Actual location, against low powered targets at ranges up to approximately 15 kilometres whilst flying at heights between 1000 and 1500 feet.

Formal Request

On 2 December 1968, the Secretary of the Army requested the Secretary of the Department of Supply to undertake the request[43]:

[42] The new equipment performed well within the accuracy parameters.

[43] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F129.



No 5826/M4/1

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF THE ARMY
MELBOURNE 3004

2 - DEC 1968

3 by Sept '69 2

2 Engrs { Sender / Recr

The Secretary,
Department of Supply,
Constitution Avenue,
Parkes, A.C.T. 2600 ~~HIGH DIVINE~~

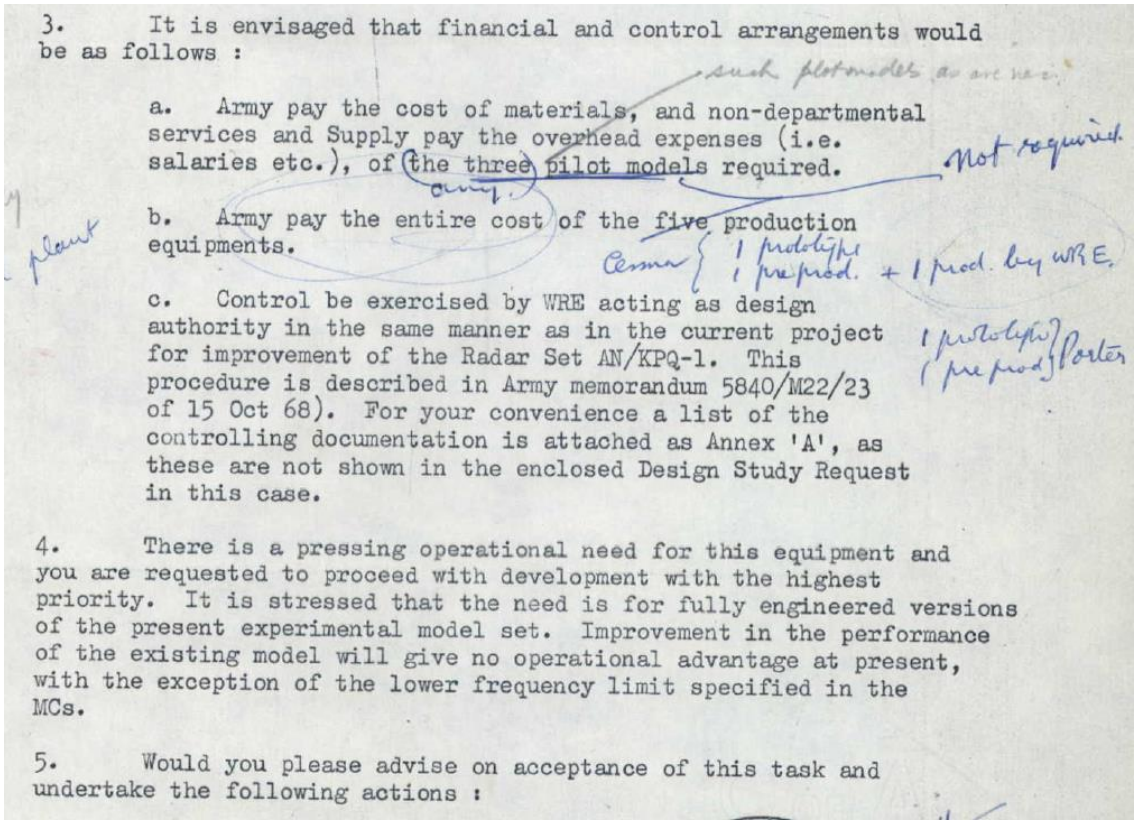
Code name suggested by DMI

AIRBORNE RADIO DIRECTION-FINDING SET

1. Your Department has already provided two experimental models of an Airborne Radio Direction-Finding Set which are currently being used in Army aircraft in Vietnam. These have proved to be very successful in operations, but being only experimental models are now degenerating rapidly under active service conditions. The Army has an urgent requirement for a further five sets. The details of the requirement are set out in Design Study Request No. 174/68 — Mil Classn Secret and AHQ Military Characteristics No. 417/1, copies of which are enclosed.

2. In order to take advantage of the familiarity of the WRE staff with the work already done, and thereby produce field equipments as quickly as possible, it would be very advantageous if this project could be undertaken by your Department.

Figure 44: Secretary of Army Letter #1



3. It is envisaged that financial and control arrangements would be as follows :

such pilot models as are nec.

a. Army pay the cost of materials, and non-departmental services and Supply pay the overhead expenses (i.e. salaries etc.), of the three pilot models required. Not required.

b. Army pay the entire cost of the five production equipments.

Cessna { 1 prototype / 1 pre prod. + 1 prod. by WRE.

c. Control be exercised by WRE acting as design authority in the same manner as in the current project for improvement of the Radar Set AN/KPQ-1. This procedure is described in Army memorandum 5840/M22/23 of 15 Oct 68). For your convenience a list of the controlling documentation is attached as Annex 'A', as these are not shown in the enclosed Design Study Request in this case.

1 prototype / 1 pre prod } Porter

4. There is a pressing operational need for this equipment and you are requested to proceed with development with the highest priority. It is stressed that the need is for fully engineered versions of the present experimental model set. Improvement in the performance of the existing model will give no operational advantage at present, with the exception of the lower frequency limit specified in the MCs.

5. Would you please advise on acceptance of this task and undertake the following actions :

Figure 45: Secretary of Army Letter #2

Military Characteristics Issued

The Army subsequently issued Military Characteristics No 417 that catered for five fully engineered ARDF units to suit two different types of aircraft; three for the Cessna and two for the Porter. The new units were to provide for increased frequency coverage, and for the equipment to be fully tested and documented. The new models are to be based on the experimental Model B.[44]

Initial Meeting – Project Thorough

On 11 December 1968, officers from the Department of Supply, Directorate of Army Communications, Directorate of Army Equipment, Army Aviation, Directorate of Military Intelligence (MI8) and WRE attended a meeting at AHQ Canberra in regard to the Airborne Direction Finding Set. Pertinent extracts of the minutes follow[45]:

Present:	Lt Col	D.J. Tier	DEP	Chairman
	Lt Col	R.A. Clark	D Sigs	
	Lt Col	B.H. Hockney	D Sigs	
	Lt Col	E.H. Hynes	D Eqpt	
	Mr.	E.B. Davis	WRE (Part time)	
	Mr.	J.E. Lamprey	WRE	
	Mr.	M.W. Higgins	WRE	
	Maj	P.R. Gower	D Eqpt	
	Maj	P.J. Calvert	DA Avn	
	Maj	B.D. Phillips	DEP	Secretary
	Maj	C.J. Cattanach	DMI	

Figure 46: Meeting Attendees

[44] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army.

[45] NAA D174 E5669/3/23 PART 1 Development and manufacture of an airborne direction finding system for department of the army. F116.

Decision	Action By:
a. The provision of the first three engineered equipments by Sep 69 was accepted by the WRE representatives as being a realistic target.	WRE
b. Priority in the engineering development is to be given to provision of equipments suitable for installation in CESSNA aircraft. But, if possible, attention is to be paid concurrently to meeting the installation requirements of PORTER aircraft. However, interest in the PORTER installation is NOT to delay the provision of the CESSNA installations.	WRE D Eqpt
c. The existing approved modifications to CESSNA aircraft, provided for the experimental equipments, are to be the basis for the installation design for the new equipments. D Eqpt is to provide WRE with copies of the appropriate RAAF aircraft modification instructions.	WRE D Eqpt
d. It is envisaged, subject to resolution at a later date, that the last two equipments will be designed specifically for installation in PORTER aircraft.	
e. Aircraft (including CESSNAs to be suitably modified) are to be made available to WRE as and when required for the Project.	DA Avn D Eqpt

Figure 47: Meeting Decisions

i. The security classifications given to aspects of this Project will now be:

Existence of Project	:	CONFIDENTIAL
Military Characteristics	:	CONFIDENTIAL
Design and Performance	:	CONFIDENTIAL

DEP is to promulgate the downgrading of Military Characteristics and Design and Performance. — DEP

j. The need for an unclassified codeword or nickname to apply to this Project was recognized. The DMI rep was requested to investigate this aspect. On 12 Dec 68 DMI issued the UNCLASSIFIED codeword "THOROUGH". — DMI

Figure 48: Project THOROUGH Named

Meetings

On 6 March 1969, the first meeting was arranged between representatives of the Department of Army and WRE for detailed discussion of the project. There were subsequent meetings between RAAF and WRE, and in the meantime Cessna and Porter aircraft were stationed at Edinburgh to allow mechanical design work to proceed.[46]

On 9 May 1969, the WRE scientists had an unofficial meeting with Major Cattanach for discussions on operational aspects.

Technical Memorandum CPD (T) 169

In April 1969, RF Treharne released a Technical Memorandum CPD (T) 169[47] relating to the Rotatable Ferrite Rod Antenna System. A copy of the Memorandum is contained at Appendix 1.

Design of New Equipment

WRE scientists and engineers progressed with the development and construction of the revamped equipment. In a letter on 20 August 1969, G Best, [engineer] made the following observations in a note to the Head of the WRE Section and Army Melbourne[48]:

> *Only a limited number of our tests were carried out on upgraded experimental model A recently at Salisbury because of Telecom Group's desire to perform extensive calibration checks. Telecom Group used new engineered D.F. head amplifier design which gave satisfactory performance over frequency range 1.5 Mhz to 7 Mhz*.
>
> *After discussions with operator & mtce* [49]*, Tech, and observation of method of operation in aircraft we have revised design of column. Height of column has been reduced and the scale has been reoriented to that of Model A. We now propose also to slightly modify radome mounting to permit rapid removal of equipment from aircraft without jacking aircraft or using pit. These changes should considerably improve operational and mtce aspects*.
> *It is now evident that the accuracy of instrument depends partially on accuracy of its alignment with centre line of aircraft and aircraft compass*.

Aircraft Parameters

On 26 August 1969, Army Melbourne advised WRE of the maximum speed and G loading for the Cessna and Porter aircraft[50]:

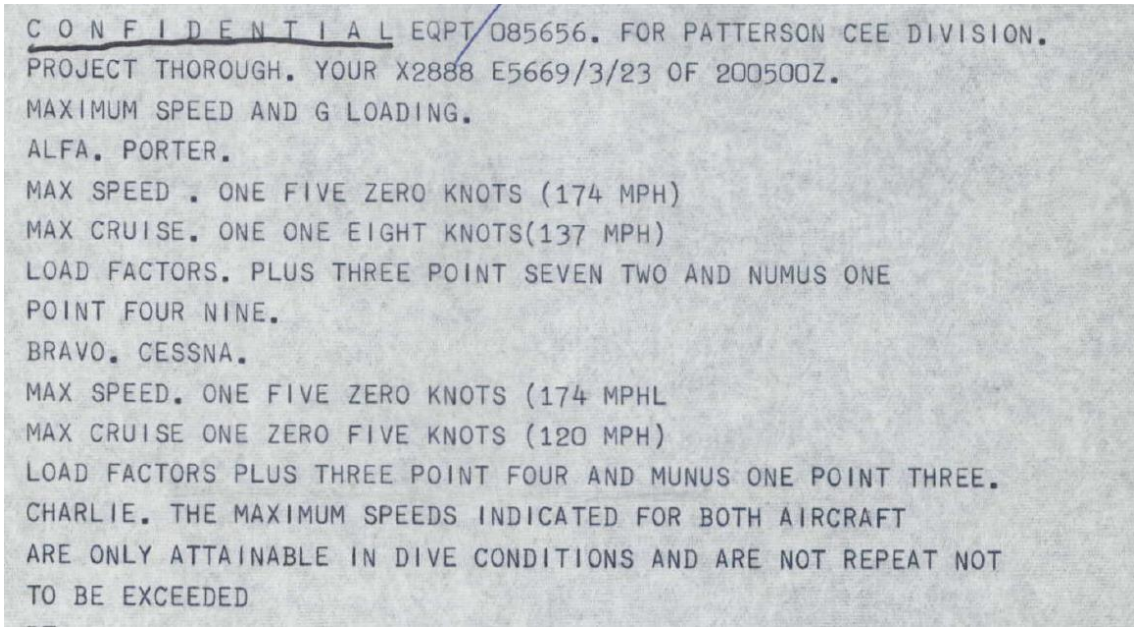
[46] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army. F21A.

[47] NAA D4884, CPD(T) 169 Technical memorandum CPD(T) 169 - Airborne high frequency direction finding for tactical use by the Australian military forces - copy number 9.

[48] Ibid, F2.

[49] Full expansion not known. Probably Maintenance.

[50] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army. F5.



C O N F I D E N T I A L EQPT 085656. FOR PATTERSON CEE DIVISION.
PROJECT THOROUGH. YOUR X2888 E5669/3/23 OF 200500Z.
MAXIMUM SPEED AND G LOADING.
ALFA. PORTER.
MAX SPEED . ONE FIVE ZERO KNOTS (174 MPH)
MAX CRUISE. ONE ONE EIGHT KNOTS(137 MPH)
LOAD FACTORS. PLUS THREE POINT SEVEN TWO AND NUMUS ONE
POINT FOUR NINE.
BRAVO. CESSNA.
MAX SPEED. ONE FIVE ZERO KNOTS (174 MPHL
MAX CRUISE ONE ZERO FIVE KNOTS (120 MPH)
LOAD FACTORS PLUS THREE POINT FOUR AND MUNUS ONE POINT THREE.
CHARLIE. THE MAXIMUM SPEEDS INDICATED FOR BOTH AIRCRAFT
ARE ONLY ATTAINABLE IN DIVE CONDITIONS AND ARE NOT REPEAT NOT
TO BE EXCEEDED

Figure 49: Aircraft parameters

Flight Trials

On 4 September 1969, WRE advised Army Melbourne of the possible flight tests and delivery times of equipment[51]:

> *Expect first hardware to be available for flight test in late December/early January. However please advise if project still has same urgency in light of rebuilding of experimental models by W.R.E. since it would be highly desirable to run full environmental tests on first prototype before flight testing and acceptance.*

Change to Antenna Column

On 8 September 1969, the Superintendent, Communications Electronics Engineering Division, WRE, wrote to other principal engineers[52]:

> *After discussions with an experienced operator of the original experimental ARDF equipment and an inspection of the equipment installed in an aircraft it has been found necessary to modify your original design by reducing column height and reorienting the scale. Tests have now shown that the column can be shortened to provide the necessary 6 ½" ground clearance required by the RAAF. These modifications are at present being incorporated in the detailed drawings.*
> *It would assist our planning if you would advise me of the new estimated completion dated for the detailed drawings, and the estimated period required for the manufacture of the first, second, and third prototypes for the Cessna aircraft.*
> *I would again stress the urgent requirement for this equipment, which is required for operational use in Vietnam, and request that you ensure that it receives highest priority.*

[51] Ibid, F11.

[52] Ibid, F12.

Notes on progress

The following handwritten note by Gordon Best[53] is on the file[54]:

22/7/69	*Details and drawings of proposed equipment rack forwarded to RAAF for comment*
4/8/69 - 15/8/69	*Experimental Model A and Cessna aircraft returned to WRE for refurbishing. Some tests made for CEE division on this equipment and several minor modifications were made to the design as a result.* *Visit of Sergeant Brill[55] (operator) and Cpl Brown[56] (Mtce Tech) to W.R.E. to participate in tests and discussions.*
5/8/69	*Visit of Sq Ldr Graf (ARDU) to discuss flight calculations*
6/8/69 – 7/8/69	*Visit of Major Gower to WRE*
13/8/69	*Fl. L Tabbagh (RAAF HQSUPCOM) visited WRE*
5/9/69	*Preparation of manufacturing drawings for electronic circuitry commenced*
29/9/69	*Detailed mechanical drawings available for checking. Copies forwarded to RAAF, ARDU, Army*
Projected Dates:	
June 30th	*Unit No 1. (Porter) Completed*
July 30th	*Unit No 2. (Porter Completed*

Interim Report

In September, Gordon Best produced a draft interim report on Project Thorough. The draft report is shown in full at Appendix 2.

[53] WRE Engineer on Project Thorough.

[54] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army. F12.

[55] Sgt Jim Brill was the Sgt I/C and operator of ARDF in 547 Sig Tp SVN April 68- Apr 69.

[56] Cpl Garth Brown was a technician with 547 Sig Tp June 67-June 68.

Figure 50: Porter aircraft with new equipment being tested at WRE

Figure 51: Equipment in the Porter

The above photograph is also in the Australian War Memorial Collection[57] (less equipment descriptions) with the following caption:

> *This brand new Pilatus PC-6 Turbo Porter aircraft (flown by army pilots of 161 Reconnaissance Flight (161 Recce Flight, attached to 547 Signal Troop, South Vietnam) has been fitted out with Aerial Direction Finding Equipment (ADFE). Fitted into the lower section of the frame are two identical, Collins 51-J4 high frequency receiver sets used to eavesdrop on and intercept enemy wireless transmissions. The set above has been fitted with a cathode ray tube and appears to be used to identify enemy band lengths and frequencies. The top unit appears to be an AKAI X-V reel to reel tape recorder used to record enemy transmissions. The small set attached to the bulkhead just inside the doorway (right) is an AN/PRC 25 wireless set, used to communicate with friendly ground troops. There is also a lookdown/side scan radar device fitted to and extending through the floor of the aircraft (left) which is possibly used as an electronic sniffer for detecting enemy movements and activities at night.*

[So many incorrect descriptions]

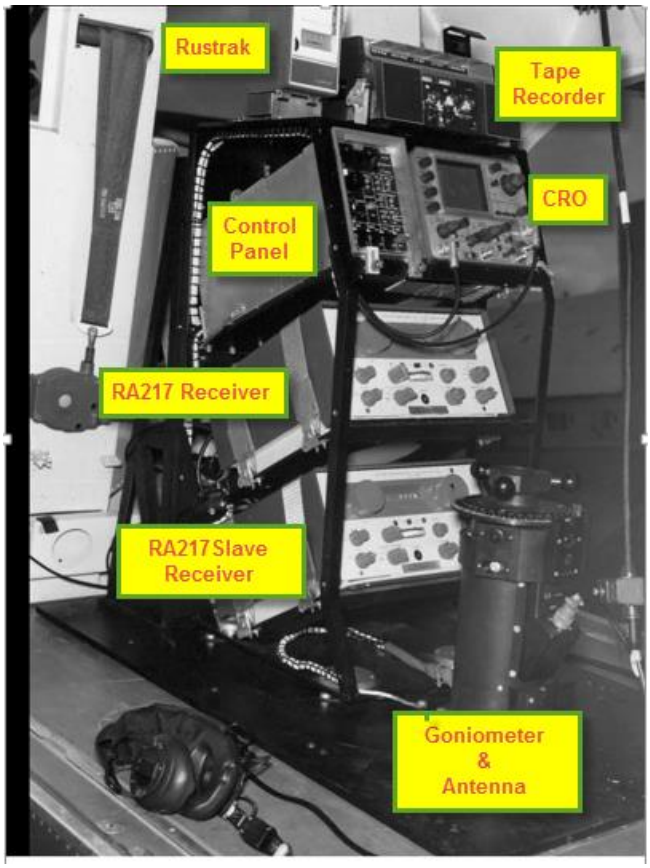


Figure 52: : Equipment in the Porter - Expanded

[57] https://www.awm.gov.au/collection/P03057.001/

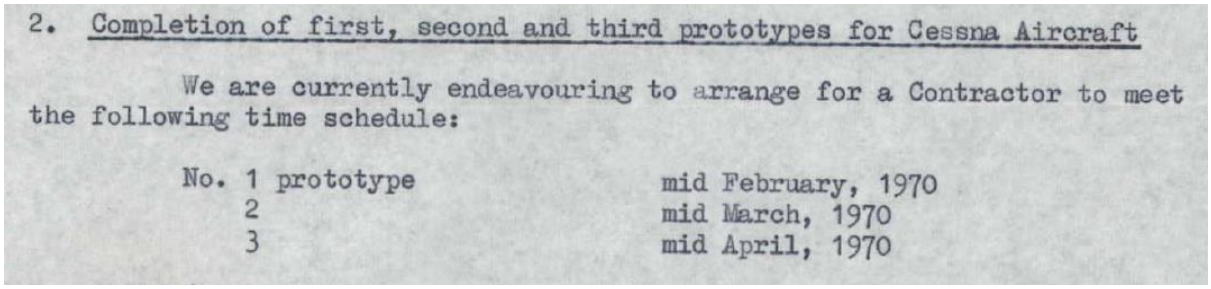
Antenna Testing

On 4 November 1969, Gordon Best sent the following signal to Army Melbourne[58]:

> *CONFIDENTIAL*
> *PROJECT THOROUGH*
> *INFORMATION FROM TREHARNE, W.R.E. INDICATES THAT THE SENSITIVITY OF UPGRADED EXPERIMENTAL MODEL A (WHICH USES OUR AREAL HEAD DESIGN) MAY BE LESS THAN THAT OF MODEL B NOW IN SERVICE. THIS IS SURPRISING SINCE OUR DESIGN COMPARED FAVOURABLY WITH THE MODEL A DESIGN, WHICH WE HAD BEEN ADVISED, WAS NOT SIGNIFICANTLY DIFFERENT TO THE MODEL B. TREHARNE IS MAKING FURTHER TESTS TO DETERMINE VALIDITY OF INFORMATION AND TO IMPROVE SENSITIVITY IF NECESSARY AND IF POSSIBLE.*

Delivery Dates

On 7 November 1969, in an internal memo, the Workshops and Mechanical Design Division informed the Superintendent Communications and Electronic Engineering of the following schedule[59]:



2. Completion of first, second and third prototypes for Cessna Aircraft

We are currently endeavouring to arrange for a Contractor to meet the following time schedule:

No. 1 prototype	mid February, 1970
2	mid March, 1970
3	mid April, 1970

Figure 53: Schedule for Cessna Aircraft Prototypes

Project Thorough Meeting

At the Project Thorough Meeting held at WRE on 19 November 1969, the following information was tabled[60]:

WRE:

Design:	*Virtually completed*
Drawings:	*Manufacturing drawings for hardware completed*
Manufacture:	*Manufacture has been delayed somewhat, awaiting agreement between WRE and Army Inspection.*

Note 1: *The design for the R.F. front end has been tested in Vietnam in the recently upgraded experimental model. Although its sensitivity compared favourably with that of the experimental Model A (and we were given to understand that there was no significant difference between experimental models A and B its maximum operating range has been found to be less than that of Experimental Model B.*

Schedule -Latest Estimate.

Completion of 1st prototype (not including environmental testing) end Feb 1970

[58] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army. F28

[59] Ibid, F30.

[60] Ibid, F49-51, F70.

2nd Prototype (not including environmental testing) end March 1970
3rd Prototype (not including environmental testing) end April 1970

Environmental testing will take about 1 month.
Acceptance testing and flight certification could take about one month in addition.

Completion of Porter models July – August 1970

Army Stated:

Number of Equipments

Stated by Maj Gower

Original 5:	*2 Cessnas - Operational*
	1 Cessna - Training use, further experiments
	2 porter - Operational
Now required:	*4th set of Hardware for Cessna,*
	And 3rd set of Hardware for Porter, to be held in Army stores system.

Modification to Porter Aircraft in SVN

On 20 November 1969. The following Confidential signal was sent from Army Melbourne to Army Canberra and AustForce Vietnam[61]:

MGO 98366. MODIFICATION OF PORTER AIRCRAFT FOR SPECIAL ROLE ARMY CANBERRA SD 46063 OF Q150202ZOCT [62] *DIRECTS CMM INTER ALIA CMM THAT THE PORTER AIRCRAFT ARE TO BE MODIFIED IN THEATRE FOR THE SPECIAL ROLE AND TRIALS ARE TO BE CONDUCTED LOCALLY USING AVAILABLE EQUIPMENT. HEADQUARTERS SUPPORT COMMAND RAAF IS THE ONLY AUTHORITY THAT CAN APPROVE AN AIRCRAFT MODIFICATION EXCEPT FOR THE RELAXATION GRANTED IN OPERATIONAL THEATRES VIDE AIR BOARD ORDER T 19/1. HOWEVER IN VIEW OF THE COMPLEXITY OF THIS MODIFICATION AND THE ABSENCE OF STRESS DETAILS OF THE PORTER AIRFRAME WHICH ARE BEING OBTAINED FROM PILATUS. NO STRUCTURAL ALTERATIONS INCL DRILLING HOLES ARE TO BE MADE TO THE PORTER AIRCRAFT CMM NOR IS THE EQUIPMENT TO BE MOUNTED IN THE PORTER CMM UNTIL DETAILS ARE CLEARED BY MGO BRANCH.*

[61] AWM 98 R5821/1/8 Project Thorough.

[62] Not on file.

On 24 November 1969, Army Canberra (MI8) sent the following signal to Defair Canberra, Army Melbourne and WRE Salisbury[63]:

> *CONFIDENTIAL INT 52048 REF CONFERENCE AIR CDRE CUMING/LT COL WHYTE OF 21 NOVEMBER 69 SUBJECT EXPERIMENTAL TESTING OF SPECIAL ELECTRONIC EQUIPMENT IN PORTER AC.*
>
> *ONE. IT IS CONFIRMED THAT THE SPECIAL EQUIPMENT IS NOW AT WRE. AS YOU KNOW CMM THIS EQUIPMENT HAS OPERATED SUCCESSFULLY IN VIETNAM IN A CESSNA OVER THE PAST THREE YEARS AND WE NOW WISH TO DETERMINE QUICKLY WHETHER IT WILL OPERATE IN A PILATUS PORTER. WE CANNOT AFFORD TO RETAIN THE EQUIPMENT IN AUST FOR MORE THAN TWO OR THREE WEEKS AS IT IS OPERATIONALLY REQUIRED IN VIETNAM. THEREFORE WE ARE ANXIOUS TO CARRY OUT THE PORTER EXPERIMENT URGENTLY AND WOULD BE GRATEFUL FOR YOUR ASSISTANCE.*
>
> *TWO. WE WILL BE ABLE TO STATION A PORTER AT WRE FOR A FEW DAYS FROM 2 DEC 69 AND WOULD HOPE THAT YOU COULD AUTHORIZE THE EXPERIMENTAL TEST AND PROVIDE ON THE SPOT ENGINEERING ADVICE AND DIRECTION TO CARRY OUT THE VERY SIMPLE MODIFICATION TO MOUNT THE EQUIPMENT IN THE AIRCRAFT. THIS MOUNTING ENVISAGED THE FASTENING OF AN ELECTRONIC EQUIPMENT RACK (ABOUT 160 LBS) TO A SEAT RAIL AND THE FITTING OF A RETRACTABLE SMALL AERIAL POD IN THE STORES DROPPING APERTURE.*
>
> *THREE. WE WOULD BE GRATEFUL OF YOUR APPROVAL OF THIS PROPOSAL AND PROVISION OF THE NECESSARY RAAF ENGINEERING ADVICE AT WRE CMM IF POSSIBLE CMM FOR 3 TO 4 DAYS COMMENCING 3 DEC 69.*

The following hand written internal WRE Minute dated 24 November [addressees unreadable possibly from R Treharne] followed on the file[64]:

> *<u>High Divine – Experimental Porter Fitment</u>*
> *See attached Army Signal P240001Z.*
> *It is proposed to see if the current experimental model can be adapted to fit the "Porter" which is now replacing the Cessna in Vietnam.*
>
> *I will be grateful of the help of your engineers on Tuesday 2nd Dec for advice on how to do this.*
>
> *You will be interested in looking at the Porter again from the view of the engineered models also.*

[63] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army. F61A.
[64] Ibid, F62.

New Equipment Arrangement

At an internal meeting at WRE on 26 November 1969, attendees discussed the possibility of fitting a second set of equipment into the Porter. The following schematic was produced[65] [66]:

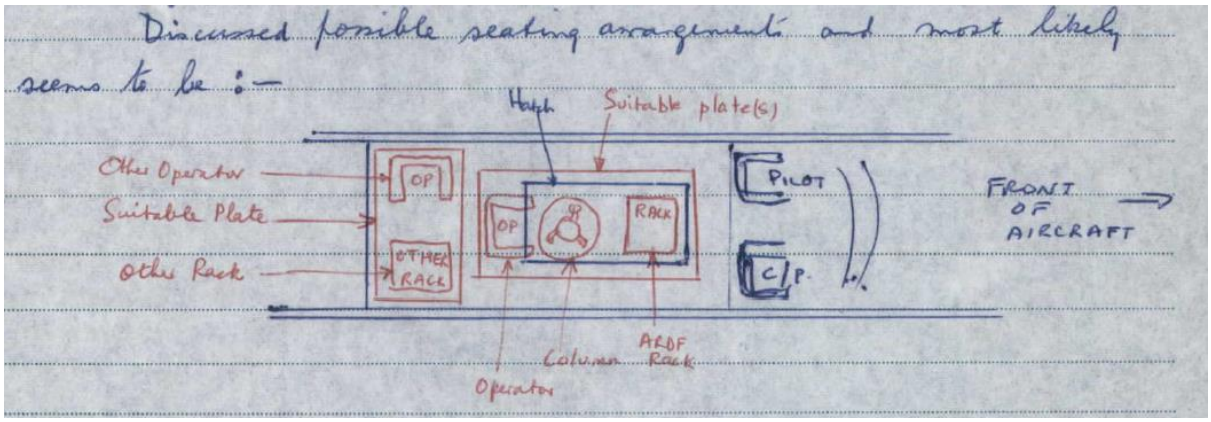


Figure 54: Fitting of additional equipment

Air Trials WRE

On 28 November 1969, Army Canberra sent a signal to WRE and Army Melbourne re testing of the equipment in the Porter[67]:

> *CONFIDENTIAL INT 52953 FOR PATERSON (ENGR) AND TREHARNE (IS). EXPERIMENTAL TESTING OF SPECIAL ELECTRONIC EQUIPMENT IN PORTER AC.*
> *FURTHER MY INT 52048 OF 240001Z.*
>
> *ONE. SUBJECT TO FINAL INSPECTION AFTER FITMENT CMM RAAF HAVE GIVEN APPROVAL FOR THE SPECIAL EXPERIMENTAL EQUIPMENT NOW HELD BY IS GROUP TO BE FLIGHT TESTED IN PORTER AIRCRAFT. RAAF WILL PROVIDE WER AM 3 DEC 69 ENGINEERING OFFICER AND CAC REPRESENTATIVE TO ADVISE ON THE FITMENTS REQUIRED.*
>
> *TWO. ARMY WILL STATION PORTER AIRCRAFT AT RAAF EDINBURGH WEF 2 DEC 69 FOR PERIOD OF UP TO TWO WEEKS IN ORDER THAT THE TRIAL MAY BE CONDUCTED. AIRCRAFT CREW WILL INCLUDE A PILOT AND TWO OPERATORS WHO HAVE HAD PREVIOUS VIETNAM EXPERIENCE IN THIS ROLE IN CESSNA AIRCRAFT. MAJ CATTANACH AHQ (DMI) WILL BE PRESENT IN THE INITIAL STAGES TO ADVISE ON THE OPERATIONAL REQUIREMENTS.*
>
> *THREE. RAAF HAVE BEEN ADVISED THAT ARMY WILL REQUIRE THAT AIRCRAFT FITMENTS ARE SUITABLE ONLY TO WITHSTAND LEVEL FLIGHT CONDITIONS AT 1500 FEET FOR THE PURPOSE OF THIS TRIAL AND THAT BETWEEN 10 AND 20 HOURS OF FLIGHT TESTING WILL BE REQUIRED.*
> *FOUR. MAIN PURPOSE OF TRIAL WILL BE TO PROVE THE SPECIAL EQUIPMENT WILL OPERATED IN PORTER AIRCRAFT AND THEREBY ENABLE WRE (ENGR) TO COMPLETE THE DESIGN OF THE ENGINEERED EQUIPMENT FOR SUBSEQUENT OPERATIONAL USE IN PORTER AIRCRAFT.*

[65] Ibid, F61. The extra positon appears to be for intercept only.

[66] This proposal did not go ahead.

[67] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army. F63Q.

Arrival of Pilatus Porter P-6 in South Vietnam

The new Porter aircraft arrived in South Vietnam on 28 November 1969[68], closely followed by new ARDF equipment[69].

Figure 55: Porter Aircraft at Nui Dat fitted with ARDF Equipment

The new prototype was basically the same as the previous model used in the Cessna but with upgraded electronics. The Porter had more room in the rear of the aircraft for passengers and equipment. The ARDF equipment rack was now located in the centre of the passenger compartment in front of the seats. . The rack was mounted on a metal plinth[70] that covered the trapdoor[71]at the bottom of the aircraft.

The antenna mount had been moved to the front of the equipment, directly in front of the operator, thus providing the operator with easier manipulation of the antenna and a better view of the goniometer readings. The antenna pod still had to be raised during landing and lowered during flight. After testing in country the new equipment became operational in January 1970. The old prototype was removed from the Cessna aircraft and became a source of spares for the newer prototype.

Testing Dates Vietnam

On 7 December 1969, Army Canberra sent the following signal to Army Melbourne and Austforce Vietnam[72].

INT 666. FOR MGO BRANCH. FLIGHT TESTING OF SPECIAL EQPT IN PORTER AIRCRAFT.

REF ALFA CLN MGO 098366 OF 280425Z NOV 69 AND BRAVO CLN TELECON MAJ CATTANACH/LT COL GRAY OF 22 DEC 69.

AS A RESULT OF A BRIEF PREPARED BY DMI DCGS HAS APPROVED FLIGHT TESTING IN VIETNAM OF SPECIAL EQUIPMENT (RELATED TO PROJECT THOROUGH) IN PORTER AC IN VIETNAM SUBJECT TO THE LIFTING OF THE BAN CONTAINED IN REF ALFA. THE TESTS ARE PROJECTED TO COMMENCE IN VIETNAM ON 16 JAN AND COINCIDE WITH THE VISIT TO 1

[68] Aircraft Nos A14-681 and 686 were the first three Pilatus Porters to be sent to Vietnam.

[69] It is believed that this equipment was an early Cessna protoype equipment modified for fittemtn into the Porter.

[70] Plinth. This enable easy removal and replacement of the equipment rack.

[71] The trapdoor was used for dropping supplies from the aircraft. The trapdoor was fixed in the open position when the equipment was installed.

[72] AWM 98 R5821/1/8 Project Thorough.

ATF OF MR RJ TREHARNE THE WRE SCIENTIST CONCERNED WITH THE EXPERIMENTAL EQUIPMENT

TWO. YOU RECALL THAT IN EARLY DEC A LIMITED FLIGHT TEST OF THE EQUIPMENT IN A PORTER TOOK PLACE AT WRE. THE EQUIPMENT WAS MOUNTED ON THE SEAT RAILS IN THE AIRCRAFT WITHOUT RPT WITHOUT MODIFICATION TO THE AIRCRAFT UNDER SUPERVISION OF RAAF SUPPORT CMD AND CAC REP. THE MOUNTING WAS CONSIDERED SAFE. THE TEST SHOWED THAT THE EQUIPMENT WOULD PERFORM SATISFACTORILY IN THE PORTER BUT WAS INCONCLUSIVE INSOFAR AS CALIBRATION AND ACCURACY COMPARED WITH THE CESSNA FITMENT. IT WAS OPERATIONALLY NECESSARY TO RETURN THE EXPERIMENTAL EQPT TO 1 ATF CMM THUS WE HAVE DECIDED ON FURTHER TESTING IN VN WITH A VIEW TO EVENTUALLY USING THE EXPERIMENTAL EQPT OPERATIONALLY IN THE PORTER AS A REPLACEMENT OR ALTERNATIVE TO THE CESSNA.

THREE. THE FITMENTS NECESSARY TO INSTAL THE EXPERIMENTAL EQUIPMENT IN THE PORTER WITHOUT MODIFICATION TO THE AIRCRAFT HAVE BEEN DESPATCHED TO 1 ATF IN ORDER THAT A SAFE AND SATISFACTORY INSTALLATION CAN BE MADE.

FOUR. WE WOULD THEREFORE BE GRATEFUL IF YOU WOULD WITHDRAW THE BAN IMPOSED BY REF ALFA AND ADVISE THIS OFFICE AND AFV AS SOON AS POSSIBLE.

There was much correspondence between Army and RAAF regarding fitment of the equipment and withdrawal of the ban. The ban was eventually lifted.

Porter Trials WRE

On 9 December 1969, Gordon Best (WRE) sent the following handwritten Minute to Telecom System Engineering (WRE)[73]:

PORTER TRIALS

Telecom group have experimental equipment mounted in Porter and consider that they have fulfilled all safety requirements./ Expecting to have flight safety test this afternoon and start taking results tomorrow (Wednesday).

Note on bottom of Minute to Mr Best*:*

Treharne advised that initial tests appear to be satisfactory. Further tests to be carried out on Friday and results then to be evaluated. Porter aircraft available for inspection by CEE & MD Gp on Thurs PM.

ARDF Testing in Vietnam

On 9 January 1970, HQ 1ATF advised the Troop and 161 Recce Flt that Army HQ had requested flight testing of the ARDF equipment in the Porter aircraft[74]. The testing was to take approximately three weeks and to assist in the testing, Sig B.J. Wilson is to be attached from Australia for the period 14 January to 18 February 1970. Mr Treharne from WRE would provide technical assistance during the trial.

[73] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army F72.

[74] Ibid.

Figure 56: Bruce Wilson with brand new greens

On 16 February 1970, Austforce Vietnam sent the following signal to Army Canberra:

REF ARMY CANBERRA EP 4893 OF 03025Z FEB 70 AND EP 5422 OF 05420Z (.) PROJECT THOROUGH (.) THE FOLLOWING ARE THE ANSWERS TO QUESTIONS POSED IN RESPECT OF BOTH CESSNA AND PORTER AIRCRAFT (.)

ONE (.) PORTER AIRCRAFT (.) ALFA (.) MAXIMUM CREW OF AIRCRAFT IS FOUR CLN PILOT CMM OBSERVER AND TWO OPERATORS (.) THE NORMAL CREW IS TWO CLN PILOT AND OPERATOR (.) BRAVO (.) IN ALL CONFIGURATIONS WEIGHT AND BALANCE ARE WITHIN LIMITS AND THERE IS NO REQUIREMENT FOR A REDUCED FUEL LOAD (.)

TWO (.) CESSNA AIRCRAFT (.) ALFA (.) NORMAL CREW FOR CESSNA IS TWO CLN PILOT AND OPERATOR (.) WHEN SECOND OPERATOR HAS BEEN CARRIED FOR TRAINING PURPOSES IT HAS BEEN NECESSARY TO REMOVE THE SECURE VOICE RADIO AND REDUCE FUEL LOAD TO BRING AIRCRAFT WITHIN AUW LIMITATIONS (.)

THREE (.) ALFA (.) MODIFICATIONS TO PORTER (.) EQUIPMENT USES INSTALLED ANTENNA AND DOES NOT REQUIRE ANY AIRFRAME MODS (.) ONLY MOD NECESSARY IS TO PROVIDE POWER SUPPLY FOR EQPT (.) THIS IS DONE BY WIRING A PLUG DIRECT TO THE BUS BAR AND THE CIRCUIT IS PROTECTED BY A 50 AMP BREAKER (.) BRAVO (.) MOD INSTRUCTIONS HAVE BEEN INITIATED BY HQ SUP COMD (.)

FOUR (.) A WRITTEN REPORT GIVING WEIGHT AND BALANCE TABLES FOR BOTH AIRCRAFT WILL FOLLOW BY POST (.)

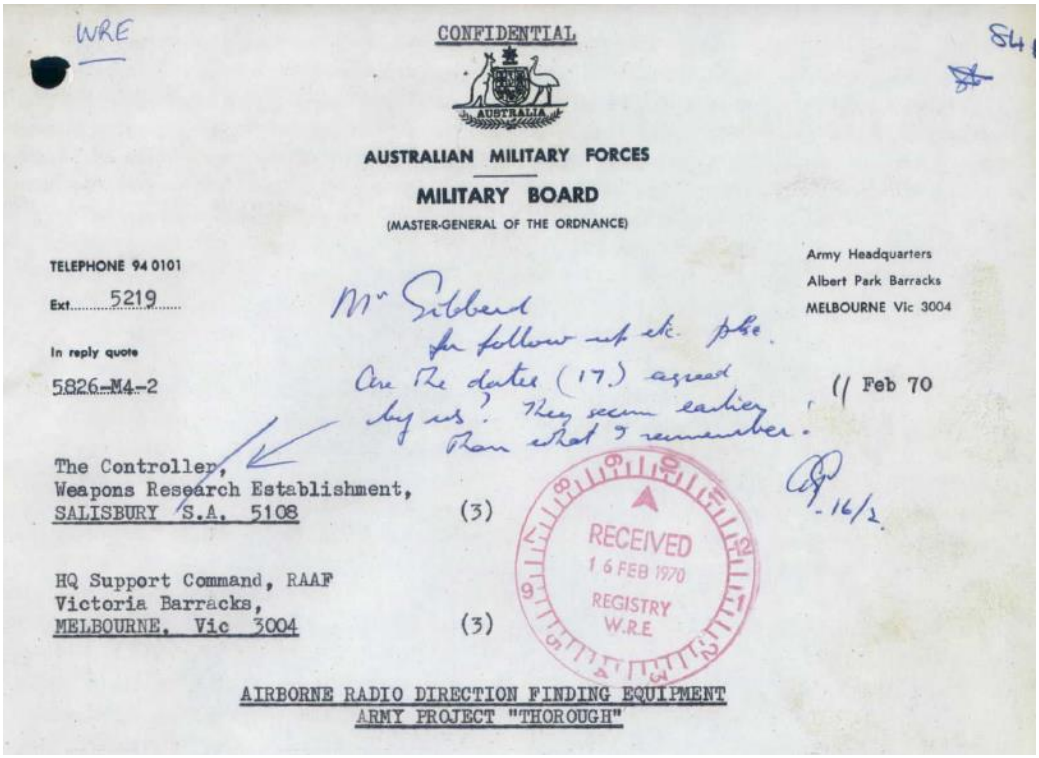
FIVE (.) IT IS INTENDED TO USE PORTER IN LIEU OF CESSNA IN THIS ROLE

Engineering Orders

In February 1970 WRE issued Engineering Orders were issued for the production of equipment.

Project Thorough Priority

On 11 February 1970, the Master General of Ordnance, Major-General Cape sent the following letter regarding Project Thorough priorities to WRE and HQ Spt Comd RAAF[75]:



WRE

CONFIDENTIAL

AUSTRALIAN MILITARY FORCES

MILITARY BOARD

(MASTER-GENERAL OF THE ORDNANCE)

TELEPHONE 94 0101
Ext. 5219

In reply quote
5826-M4-2

Army Headquarters
Albert Park Barracks
MELBOURNE Vic 3004

Mr Gibbard
For follow up etc. phone.
Are the dates (17.) agreed by us? They seem earlier than what I remember.

11 Feb 70

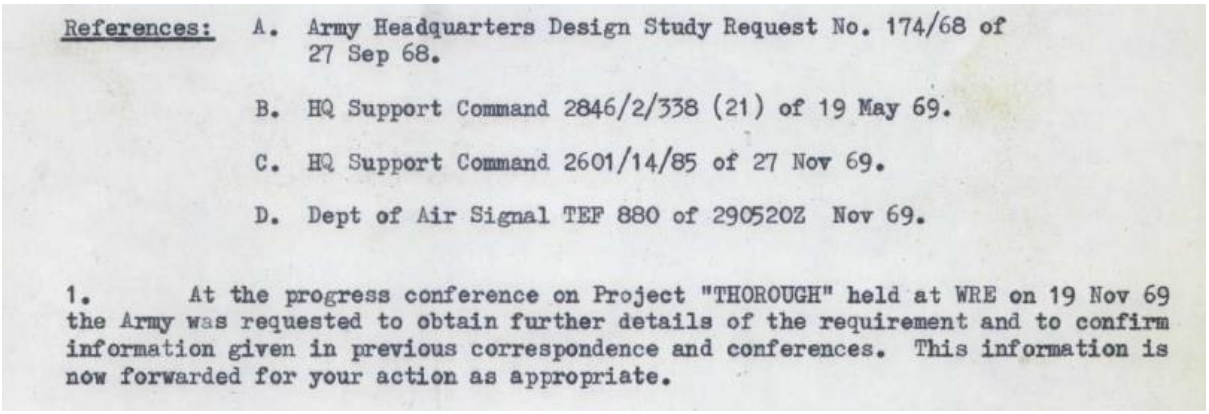
The Controller,
Weapons Research Establishment,
SALISBURY S.A. 5108 (3)

HQ Support Command, RAAF
Victoria Barracks,
MELBOURNE, Vic 3004 (3)

RECEIVED
16 FEB 1970
REGISTRY
W.R.E

AIRBORNE RADIO DIRECTION FINDING EQUIPMENT
ARMY PROJECT "THOROUGH"

Figure 57: Project Thorough Priorities #1



References: A. Army Headquarters Design Study Request No. 174/68 of 27 Sep 68.

B. HQ Support Command 2846/2/338 (21) of 19 May 69.

C. HQ Support Command 2601/14/85 of 27 Nov 69.

D. Dept of Air Signal TEF 880 of 290520Z Nov 69.

1. At the progress conference on Project "THOROUGH" held at WRE on 19 Nov 69 the Army was requested to obtain further details of the requirement and to confirm information given in previous correspondence and conferences. This information is now forwarded for your action as appropriate.

Figure 58: Project Thorough Priorities #2

[Copy - Parts highlighted by Bob Hartley]

Operational Urgency

2 The operational requirements for this equipment were set out in reference 'A' which was passed to Dept of Supply under Dept of Army Memorandum 5826-M-4-1 of 2 Dec 68. The pressing need for this equipment in the field and the consequent Desirability of allocation of high priority were stressed.

[75] Ibid, F84P.

3. The importance of this project was originally stated in a signal from the Commander, Australian Force Vietnam (AFV) to the Chairman, Chiefs of Staff Committee which reads, in part:-

> ***"The importance of ARDF in our operations needs no elaboration and any steps to improve its performance at this stage would be of no operational advantage. The principal step appears to be the production of a fully engineered version of the present experimental equipment."***

4. *The urgency of the requirement was again mentioned in reference 'B' and* ***the situation in VIETNAM is now precarious****. One of the two experimental equipments was withdrawn from operations in Dec 69 and returned to WRE for complete overhaul. whilst this has given AFV a further breathing space the situation is unsatisfactory as the second experimental equipment is NOT a reliable back-up to the one normally used on operations, and there is an ever present risk of total loss by enemy action or accident.*

5. The brief and limited proving trials carried out at WRE in Dec 69 with the experimental equipment mounted in a PORTER aircraft, and subsequent continuation trials in a PORTER in VIETNAM have provided encouraging results but it is considered premature to draw any final conclusions regarding the suitability of the PORTER fitted with the present equipment until many more hours have been flown. AFV can only carry on such trials as a secondary activity after current operational demands have been met by CESSNA sorties.

Priorities and Quantities

6. The development of an ARDF equipment for the CESSNA must remain top priority *at present due to:*

a. The inconclusive results so far achieved in the limited use of PORTER in this role

b. The general shortage of PORTER aircraft which necessitates retaining two CESSNA aircraft in VIETNAM for this task for the immediate future.

7. There is a further requirement for a ***third CESSNA aircraft to be fitted out for training****, experimentation and reserve in Australia,* ***and for two PORTER aircraft to be fitted as soon as they become available to take over the task in VIETNAM.***

8. It is intended that ultimately the configuration installed in the PORTER should be electrically identical, to that being developed for CESSNA but physically laid out to suit the PORTER appropriately. Nevertheless it is also highly desirable that the rack of equipment developed for the CESSNA be directly transferable to the PORTER, with a view to rapid changeover from one type of aircraft to the other in theatre to preserve operational flexibility.

9. There is also a requirement for Army to have a complete spare equipment held in reserve in Australia against the possibility of total loss of an operational aircraft. To this end the Army has acquired a sixth set of "in aid" receivers, recorders and oscilloscopes which are held earmarked in depot. A spare additional rack, control box and antenna etc is required to be supplied by WRE for each type of aircraft for the same reason. Additional spare modules and other replacement pars to an appropriate scale will also be required for use in field maintenance.

Flight Envelope

10. The flight envelope desired for both CESSNA and PORTER aircraft with the equipment in the operating position is as follows:

a. Normal operating ***altitude 2000 to 3000 feet AGL****.*
b. Maximum indicated ***air speed 100 knots****.*
c. Turns restricted to not above 30 degrees angle of bank.
d. Load factor minus 0-5 to plus 2.

e. *Aircraft to retain ability to perform maximum performance short take-off and landing from SOD airstrip, with the equipment retracted.*

11. It would be preferable for the aircraft to retain their normal flight envelope when the equipment is retracted to permit normal speeds, load factors etc for positioning the aircraft in the area of operations. However if you consider that such a requirement would unduly prolong the trials the restriction listed in paragraph 2 would be acceptable in the short term.

Location of Trials

12. As it will help it expedite the completion of the project if calibration of the equipment can be carried out concurrently with flight trials it is requested that the venue of the trials be at Edinburgh. It is appreciated that this will somewhat disrupt the normal workload of ARDU but it is considered that the operational urgency justifies this departure from normal procedure.

13. It is also requested that the flight testing be done as quickly as possible as soon as the equipment is available. Army will position a CESSNA and PORTER aircraft with electrical system suitably modified at Edinburgh when required for trials. Whilst this can normally be arranged at short notice a forecast of the date and duration of fitting and trials would be appreciated as soon as possible.

Inspection and Tests

14. Inspection arrangements have been discussed between Army Inspection Service (AIS), RAAF QCB and WRE. AIS will inspect the equipment on the ground and clear for installation. After additional inspection and approval by QCB the final inspection certificate will be issued.

15. In order to expedite the whole project it has been decided that:

a. *"Burn-in" tests only should be conducted on Equipment No. 1.*
b. *Environmental tests should be carried out on Equipment No. 2.*
c. *If no changes result from these environmental tests, "burn-in" testing only should be carried out on Equipment Nos 3, 4, and 5 and the spare special items mentioned in Paragraph 9.*

Forecast of Events

16. The original target date for completion of the project of Sept 69 was not achieved due to:

a. *Unforeseen delays in delivery of "in-aid" items.*
b. *The difficulty fo WRE of engineering a copy of an equipment without having access to the original model or complete technical data thereon.*

17. It is now considered that the following time-table should be aimed at:

a. Final assembly and testing of first prototype by end of Feb 70.
b. Hand over (without environmental testing) of first prototype by mid March.
c. *Flight trials by ARDU early April.*

18. *Based on this timetable the earliest date by which* ***the first equipment could be delivered in VIETNAM is mid April 1970****, assuming it passes all tests and trials and no further unforeseen difficulties arise.*

19. Addressees are requested to continue to allot high priority effort to this project and to advise this headquarters if any further information is required.

Project Slippage

On 17 February 1970, the Superintendent Communications & Electronic Engineering Division WRE, sent the following letter [*part only extracted*] to the Principal Engineer, Mechanical Design Group, WRE[76]:

> *CONFIDENTIAL*
>
> *The Department of the Army has advised that, because of slippages in the design and manufacture of the three units for Cessna aircraft, there is an urgent requirement to fit the three units in their Cessna form to Porter aircraft in Vietnam after acceptance testing in Cessnas at Salisbury. This will be an interim arrangement until the total equipment requirements for the Porter can be specified and the equipment manufactured.*

Porter Conversion Kits

During a visit of Army Personnel to WRE on 5 March 1970, WRE agreed to manufacture three Porter conversion kits and to manufacture only one Cessna mounting kit (units 2 and 3 to be reworked). Manufacture of new Porter shaft would commence on 9 March and should take about one week[77].

Cessnas to be Withdrawn

In a letter from the Department of the Army to WRE on 23 March 1970, withdrawal of the Cessna aircraft from Vietnam was advised[78]:

> *The CESSNA aircraft is likely to be withdrawn from service in South Vietnam in April, 1970. It is therefore proposed that the minor modifications necessary to fit the first three prototype equipments in PORTER aircraft should be undertaken immediately by WRE. Subject to RAAF approval, these equipments would now be flight tested in the PORTER aircraft, but still to the restricted flight envelope as envisaged for the CESSNA aircraft. The trials would remain scheduled for the 20 Apr 70.*
>
> *As formal approval for flight testing these equipments in a PORTER aircraft may not be forthcoming from the RAAF, to prevent slippage of the project at the last critical stage, it will still be necessary to maintain one equipment suitable for fitting, and flight testing in the CESSNA aircraft. This equipment would still be available for training use in AUSTRALIA, if required.*

[76] Ibid, F86.

[77] Ibid, F97.

[78] Ibid, F114.

Swiss Not Happy

The following article appeared in an Australian newspaper[79]:

Plane will not go to Vietnam

CANBERRA — The Australian Government has given an undertaking to Switzerland that it will not use its newest Pilatus Porter aircraft in Vietnam.

The Swiss Government insisted on the undertaking before authorising delivery of the plane.

The Australian Army has ordered 19 of the Swiss-built light aircraft at a cost of $116,000 each.

When one of the planes crashed and burned while on a bird-dogging mission in Vietnam, the Swiss Government learned for the first time that Australia was using them there.

At that stage 15 of the planes had been delivered, and the Swiss Government placed an immediate ban on further deliveries.

Switzerland demanded that the three remaining Pilatus Porters be withdrawn from Vietnam before it would allow deliveries of other planes ordered.

However, defence sources said last night that approval was given for delivery of the 16th aircraft when the Australian Government undertook not to use it in Vietnam.

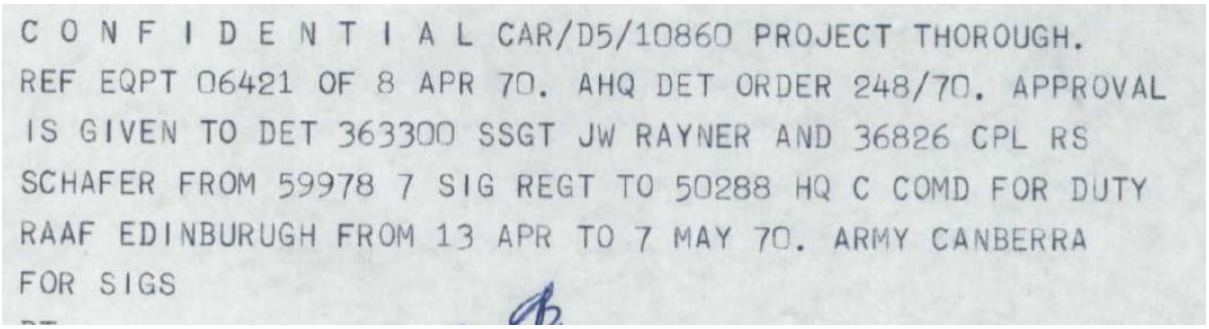
The question of delivery of the remaining three aircraft, which have not been completed, is still under discussion.

Figure 59: Paper article

[79] Date and paper not identified. 'Bird-dogging'?? Aircraft were not withdrawn.

Operators for Trials

On 13 April 1970, ARDF operators SSgt Jim Rayner and Cpl Dick Schafer were approved to attend the trials[80]:



CONFIDENTIAL CAR/D5/10860 PROJECT THOROUGH. REF EQPT 06421 OF 8 APR 70. AHQ DET ORDER 248/70. APPROVAL IS GIVEN TO DET 363300 SSGT JW RAYNER AND 36826 CPL RS SCHAFER FROM 59978 7 SIG REGT TO 50288 HQ C COMD FOR DUTY RAAF EDINBURUGH FROM 13 APR TO 7 MAY 70. ARMY CANBERRA FOR SIGS

Figure 60: Op Sigs to attend trials

WRE Engineer to Deploy to Vietnam

On 17 April 1970, the Department of Army, Melbourne, wrote to the Secretary, Department of Supply, re the provision of an engineer to assist in the operational deployment of the new ARDF equipment[81]:

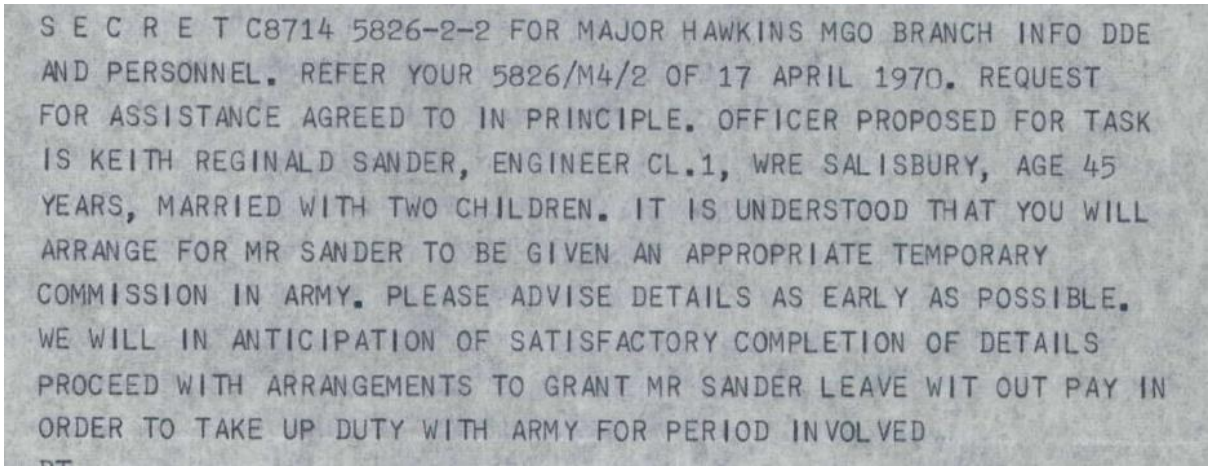
> [Extract] *You will be aware that WRE has been acting as Design Authority for the above project* [Project Thorough]. *The stage has now been reached where flight tests, functional checks and calibration of a completely engineered equipment are taking place. On completion of this work, its first equipment will be despatched immediately to South Vietnam for installation in a PORTER aircraft and operational use.*
>
> *Although experimental models of this equipment have been in use in South Vietnam for some time, the physical configuration of the engineered equipment is quite different. Because of the operational urgency for the equipment, it is being sent to South Vietnam having completed only limited testing and with very basic documentation. This creates a very difficult position for our Aviation Workshop in South Vietnam.*
>
> *It is therefore considered to be imperative that a member of the WRE Design Engineer Team arrives in South Vietnam at the same time as the equipment in order to:*
>
> a. *Supervise and assist with the installation of the equipment.*
> b. *Supervise the first operational flights and help to deal with any early maintenance problems.*

On 14 May 1970, Canberra advised HQ AFV, HQ 1ATF and 547 Sig Tp that Captain KR Sanders of WRE would be visiting the troop from 27 May to 28 June for the installation of new ARDF equipment.[82]

[80] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army F141.

[81] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army . F148a.

[82] AWM 98 R5821/1/8 Project Thorough.



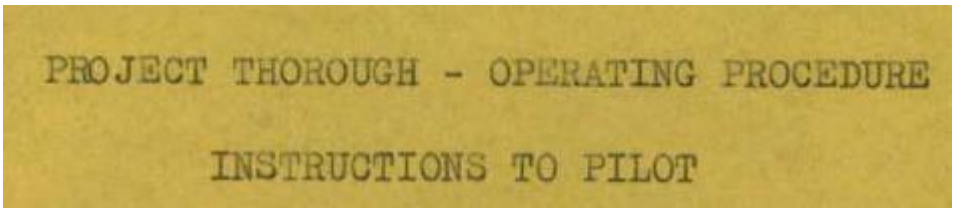
S E C R E T C8714 5826-2-2 FOR MAJOR HAWKINS MGO BRANCH INFO DDE AND PERSONNEL. REFER YOUR 5826/M4/2 OF 17 APRIL 1970. REQUEST FOR ASSISTANCE AGREED TO IN PRINCIPLE. OFFICER PROPOSED FOR TASK IS KEITH REGINALD SANDER, ENGINEER CL.1, WRE SALISBURY, AGE 45 YEARS, MARRIED WITH TWO CHILDREN. IT IS UNDERSTOOD THAT YOU WILL ARRANGE FOR MR SANDER TO BE GIVEN AN APPROPRIATE TEMPORARY COMMISSION IN ARMY. PLEASE ADVISE DETAILS AS EARLY AS POSSIBLE. WE WILL IN ANTICIPATION OF SATISFACTORY COMPLETION OF DETAILS PROCEED WITH ARRANGEMENTS TO GRANT MR SANDER LEAVE WIT OUT PAY IN ORDER TO TAKE UP DUTY WITH ARMY FOR PERIOD INVOLVED

Figure 61: Mr Sanders to receive temporary commission[83]

On 25 May, Captain Sander's visit was cancelled, and on 28 May, Major Best, the Project Engineer from WRE was nominated and approved to visit from 17 June to 16 June 1970.[84]

Pilot Instructions

After discussions with Lt D Gerard[85], Air Army, on 21 May 1970, G. Best issued the following Project Thorough Operating Procedure – Instructions to Pilot[86].



PROJECT THOROUGH - OPERATING PROCEDURE

INSTRUCTIONS TO PILOT

The pilot is required to fly courses past the suspected location of transmitters. The courses are to be defined by 6 figure grid references of the start and finish points, and should be flown at a constant speed and constant altitude.

The following list details the action required of the pilot.

(1) The pilot is to be briefed by the operator on approximate areas to work and courses to be flown.
(2) The approximate start and finish points of runs should be pre-planned where time is important.
(3) Runs must be made at a predetermined constant speed (approximately 100 knots in Porter) and a constant balanced heading is essential. Wings should be level at all times since wing roll will result in bearing inaccuracies.
(4) As he passes over the start point, the Pilot should advise the operator and should note the 6 figure grid reference of the point.
(5) At the conclusion of each run the Pilot will advise the operator:
  (a) The constant heading
  (b) Start point (6 figure grid)
  (c) Finish point (6 figure grid)
(6) The Pilot should ensure that the hatch doors are CLOSED for takeoff and landing because it is important not to allow an accumulation of dust and oil on the equipment. The hatch doors should therefore not be removed.

[83] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army F148.

[84] Ibid.

[85] Dave Gerard had previously flown ARDF missions in SVN in Cessna aircraft.

[86] NAA D174 E5669/3/23 PART 2 Development and manufacture of an airborne direction finding system for department of the army F157.

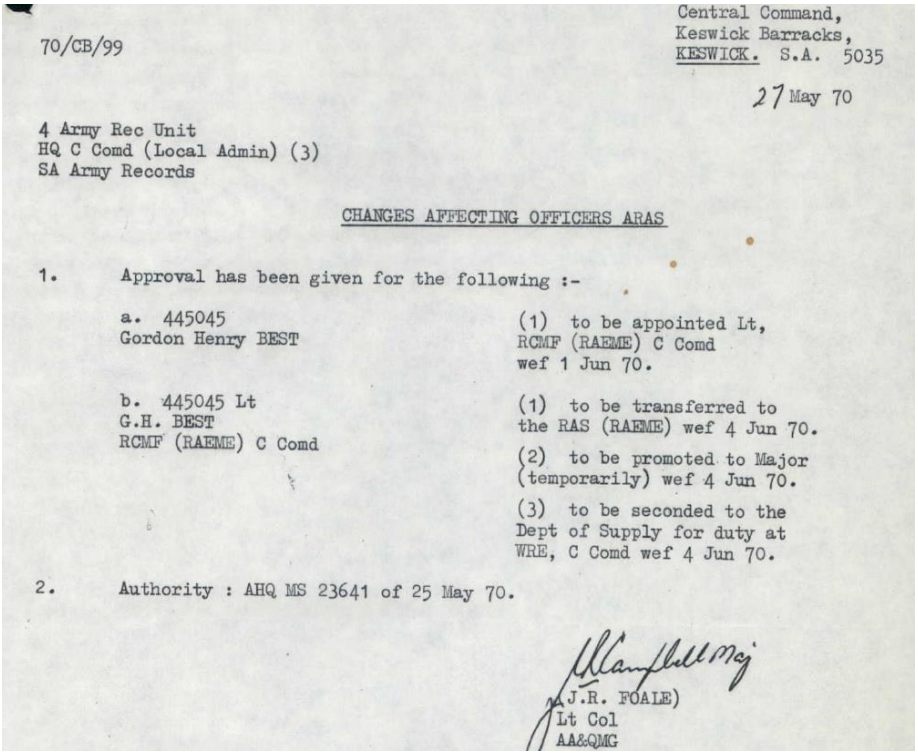
Cost Estimates for New Design

In a signal on 25 May 1970, WRE requested Army to provide new information to enable WRE to complete cost estimates[87]:

> *PROJECT THOROUGH*
>
> *SUPPLY HEAD OFFICE HAVE REQUESTED THAT WE PREPARE A NEW TECHNICAL COST PLAN INCORPORATING LATEST ARMY REQUIREMENTS AND EQUIPMENT QUANTITIES.*
>
> *WE THEREFORE PROPOSE TO BASE INITIAL ESTIMATE ON DESIGN AND MANUFACTURE OF THREE UNITS, INCLUDING SPARES, FOR CESSNAS, MODIFIED TO SUIT PORTERS. THREE SETS OF HARDWARE FOR THIS INITIAL REQUIREMENT ARE BEING MANUFACTURED AND ARE NEAR COMPLETION.*
>
> *PLEASE CONFIRM THAT THREE UNITS OF THIS KIND WILL MEET YOUR INITIAL REQUIREMENTS.*
>
> *IN THE FUTURE WE WISH TO PREPARE A SEPARATE ESTIMATE FOR YOUR ADDITIONAL EQUIPMENT OPERATING IN 1.5 – 7.0 MHz BAND WHICH WE UNDERSTAND COULD INCLUDE TWO OPERATING POSITIONS AND A SEMI AUTOMATED DESIGN.*
>
> *WE WILL EXAMINE THIS REQUIREMENT AFTER DESPATCH OF THE INITIAL UNIT AND WOULD EXPECT TO DISCUSS THIS LATER WE YOU. WE WOULD LIKE TO HAVE AN INDICATION OF THE NUMBER OF UNITS REQUIRED TO THE REVISED DESIGN.*

New WRE Engineer for Vietnam Deployment

On 17 May 1970, Gordon Best was temporarily commissioned into the Army wef 1 Jun 70[88]. The visit to the Troop was approved for 10 Jun to 10 Jul 70.



70/CB/99

Central Command,
Keswick Barracks,
KESWICK. S.A. 5035

27 May 70

4 Army Rec Unit
HQ C Comd (Local Admin) (3)
SA Army Records

CHANGES AFFECTING OFFICERS ARAS

1. Approval has been given for the following :-

a. 445045
Gordon Henry BEST

(1) to be appointed Lt, RCMF (RAEME) C Comd wef 1 Jun 70.

b. 445045 Lt
G.H. BEST
RCMF (RAEME) C Comd

(1) to be transferred to the RAS (RAEME) wef 4 Jun 70.

(2) to be promoted to Major (temporarily) wef 4 Jun 70.

(3) to be seconded to the Dept of Supply for duty at WRE, C Comd wef 4 Jun 70.

2. Authority : AHQ MS 23641 of 25 May 70.

J.R. FOALE)
Lt Col
AA&QMG

Figure 62: G Best appointment

[87] Ibid, F158.

[88] Ibid, F161.

Deployment Delayed

On 2 Jun, Army Melbourne informed Army Canberra that the delivery of the new equipment would be slipped[89].

C O N F I D E N T I A L.EQPT072191.PROJECT THOROUGH.REFERENCE
SD24313 OF 280445Z MAY.FINAL CHECKOUT OF EQUIPMENT HAS
SHOWN NEED TO REWIRE SECTIONS OF CONTROL AND POWER SUPPLY UNIT
TO IMPROVE RELIABILITY.UNFORTUNATELY THIS WILL CAUSE PROGRAMME
TO SLIP BY ONE WEEK .EQUIPMENT WILL NOW BE DELIVERED TO
RICHMOND BY 0900 17 JUN.REQUEST MAJOR BEST BE TRANSFERRED
FROM CHARTER FLIGHT 10 JUN 70 TO NEAREST CHARTER FLIGHT TO
17 JUN 70.REQUEST ALSO ATTACMENT DATES BE AMENDED TO 17 JUN 70
TO 16 JUL 70.ARMY CANBERRA FOR S D CMM MILSEC AND PS(A).

Figure 63: Delivery and attachment dates changed

Air Safety Requirements

On 9 June, the Superintendent of Workshops and Mechanical Design confirmed that all the requirements for air safety had been met[90].

TO : SUPERINTENDENT, C.E.E. DIVISION. (ATTENTION: MR. R. PATERSEN) 11.6.70
REGISTRY USE ONLY
FROM : (Branch or Estab.) SUPERINTENDENT, WORKSHOPS & MECHANICAL DESIGN.
OUR FILE NO. K5834/3/16
DATE 9 JUN 1970
REFER : E. CEELY EXT'N. 396
Reference : E5669.3.23
Subject : AIR SAFETY APPROVAL FOR PORTER INSTALLATION

With reference to your memorandum dated 25th May, 1970 enclosing a copy of memorandum from C.A.C. to R.A.A.F. resident engineer dated 8th April, 1970, we wish to confirm that all requirements under paras. 1, 2 and 3 have been met.

2. We also attach herewith 4 off prints of installation drawing 90376D to forward to C.A.C. which covers those details requested under sub-paras. 3(a) to 3(e) of their memorandum, as well as nominating weights and C of G's of equipment used in D.F. installation for Porter aircraft.

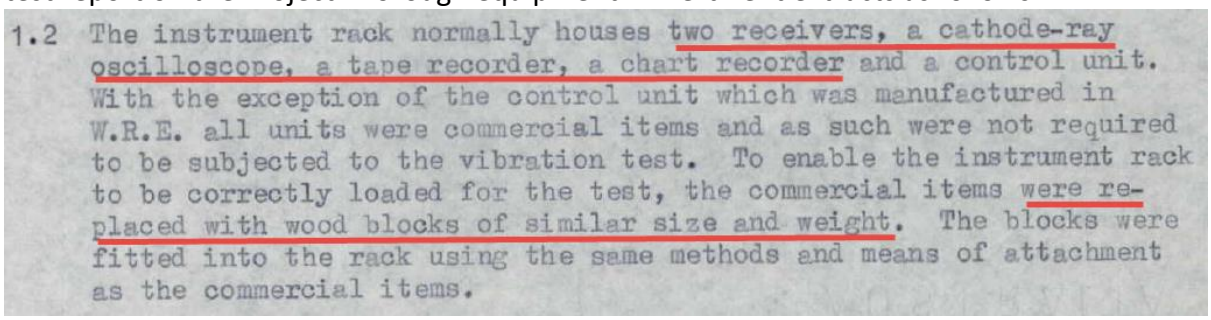
Harry Ford
for SUPERINTENDENT
WORKSHOPS & MECHANICAL DESIGN

Figure 64: Air Safety Requirements

[89] NAA: D174, E5669/3/23 Part 3. Development and manufacture of an airborne direction finding system for department of the army. F4.
[90] Ibid, F10.

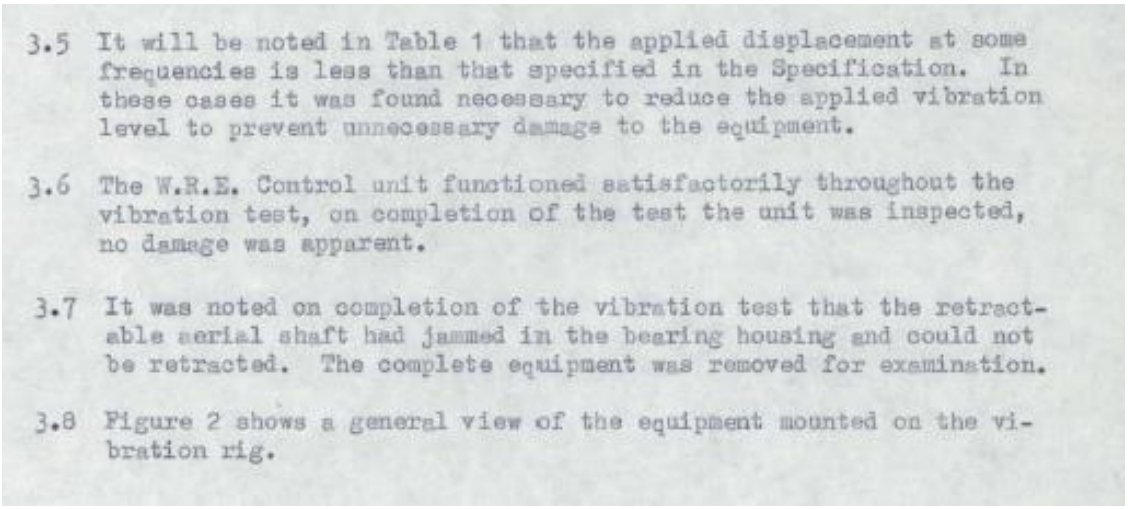
Environmental Testing

On 10 June, the WRE Engineering Wing, Central Test House, released their environmental test report on the Project Thorough equipment[91]. Pertinent extracts as follows:



1.2 The instrument rack normally houses two receivers, a cathode-ray oscilloscope, a tape recorder, a chart recorder and a control unit. With the exception of the control unit which was manufactured in W.R.E. all units were commercial items and as such were not required to be subjected to the vibration test. To enable the instrument rack to be correctly loaded for the test, the commercial items were replaced with wood blocks of similar size and weight. The blocks were fitted into the rack using the same methods and means of attachment as the commercial items.

Figure 65: Commercial equipment replaced



3.5 It will be noted in Table 1 that the applied displacement at some frequencies is less than that specified in the Specification. In these cases it was found necessary to reduce the applied vibration level to prevent unnecessary damage to the equipment.

3.6 The W.R.E. Control unit functioned satisfactorily throughout the vibration test, on completion of the test the unit was inspected, no damage was apparent.

3.7 It was noted on completion of the vibration test that the retractable aerial shaft had jammed in the bearing housing and could not be retracted. The complete equipment was removed for examination.

3.8 Figure 2 shows a general view of the equipment mounted on the vibration rig.

Figure 66: Test Results

[91] Ibid, F33-39.

FIGURE 2

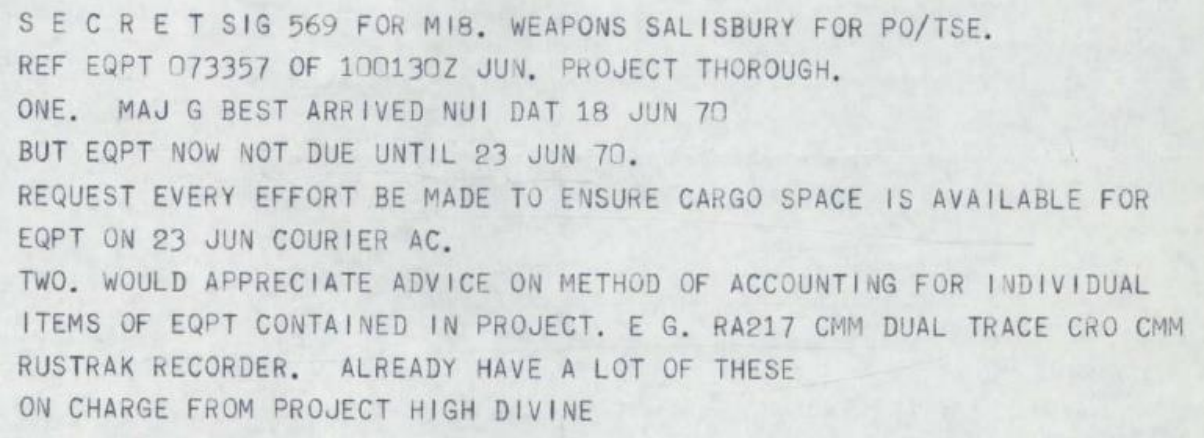
General view of Equipment shown mounted on vibration test rig. Aerial is shown in lowered position.

Figure 67: Test Rig

Maj Best Arrives

On 19 June, 547 Sig Tp advised Army Canberra and other agencies that Maj Best had arrived and that equipment was not due to arrive until 23 Jun[92].

[92] Ibid, F16.



S E C R E T SIG 569 FOR MI8. WEAPONS SALISBURY FOR PO/TSE.
REF EQPT 073357 OF 100130Z JUN. PROJECT THOROUGH.
ONE. MAJ G BEST ARRIVED NUI DAT 18 JUN 70
BUT EQPT NOW NOT DUE UNTIL 23 JUN 70.
REQUEST EVERY EFFORT BE MADE TO ENSURE CARGO SPACE IS AVAILABLE FOR
EQPT ON 23 JUN COURIER AC.
TWO. WOULD APPRECIATE ADVICE ON METHOD OF ACCOUNTING FOR INDIVIDUAL
ITEMS OF EQPT CONTAINED IN PROJECT. E G. RA217 CMM DUAL TRACE CRO CMM
RUSTRAK RECORDER. ALREADY HAVE A LOT OF THESE
ON CHARGE FROM PROJECT HIGH DIVINE

Figure 68: Maj Best arrived

Pre Delivery Discussions

On 22 June, Gordon Best sent a signal to WRE and Army Melbourne regarding background discussions held with operator and maintenance staff at the Troop on the performance of the current equipment[93]. Pertinent extracts follow:

> *2. OPERATIONAL EXPERIENCE HAS SHOWN THAT RESULTS VARY CONSIDERABLY WITH TYPE OF AERIAL USED BY EN AND ALSO THE TERRAIN IN WHICH EN IS LOCATED. THIS SUGGESTS THAT WRE OR ARMY SHOULD PLAN FOR EXTENSIVE TRIAL ON SECOND UNIT IN AUST.*
> *3. SOME CALIBRATION BEING DONE ON EXPT MODEL AND PLAN TO DO SOME ON NEW EQPT. DATA REDUCTION IS A PROBLEM AND COULD YOU OBTAIN OLIVETTI PROGRAMME PREVIOUSLY USED BY IS GROUP FOR THIS PURPOSE AND ADVISE BY SIG QUERY.*

In a later signal Gordon Best also informed WRE that the Troop had requested the inclusion of a second headset position in the equipment for training purposes.

New Equipment Arrived and Tested

The new equipment arrived on 25 June and was installed in an aircraft on 26-27 June and testing was scheduled to commence on 27 June.

ARDF Tests

On 3 July, Gordon Best sent the following signal to WRE[94]:

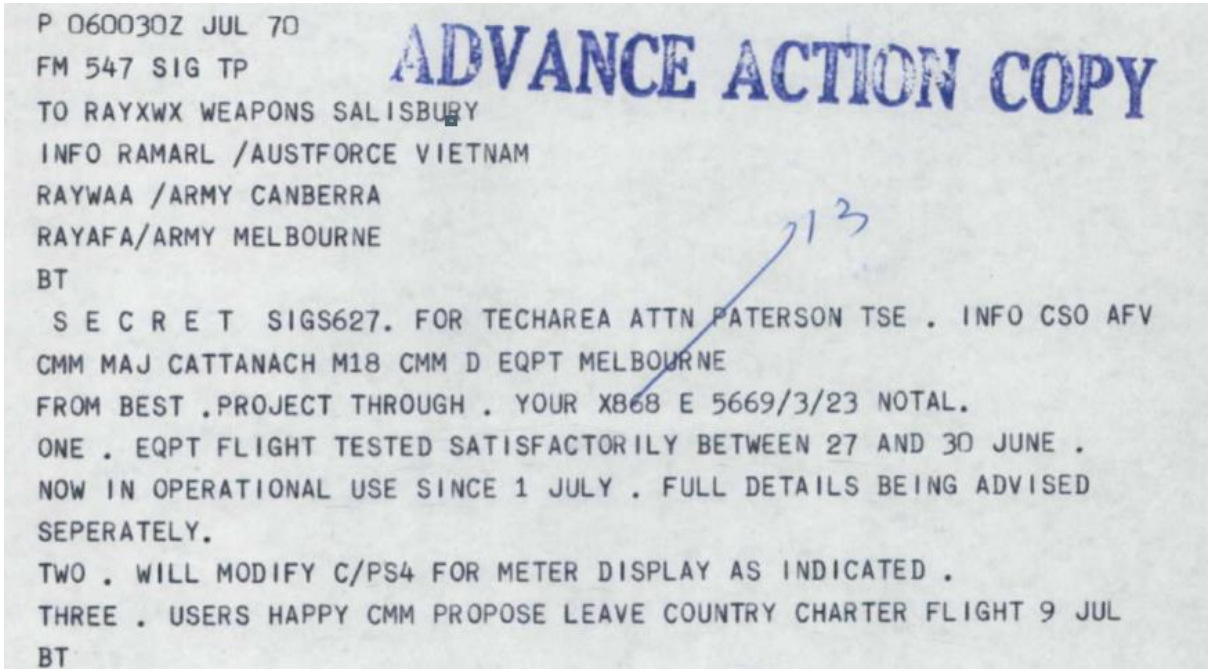
> *ONE. YOUR E5669/3/23 O JUL 70 ACKNOWLEDGED.*
> *TWO. SENSITIVITY MEASURED USING SANDER LOOP METHOD IN AIRCRAFT VARIES FROM APPROX SIXTY DV REF ONE MICROVOLT AT LOW END TO APPROX FORTY SEVEN DB AT HIGH END. POWER SUPPLY INTERFERENCE IS NOT SIGNIFICANT.*
> *THREE. EQUIPMENT INSTALLED IN AIRCRAFT (AC) ON 27 JUN. SEAT RAIL SPACERS (SHIMS) WERE TOO TIGHT AND WERE MILLED OUT APPROX ONE SIXTEENTH INCH AT VUNG TAU. FOAM PLASTIC SEAL SOMEWHAT TOO THICK AND SOLID AND IMPEDED INSTALLATION, DOOR PLUNGER TOO SHORT HENCE USELESS BUT PILOT DISLIKED CLOSING HATCH DURING FLIGHT ANYWAY. BUNGEE SYSTEM NOT REQUIRED. DRILL JIG NOT PROVIDED WITH ADDITIONAL LOCATING DEVICES BUT SATISFACTORY.*
> *FOUR. FLIGHT TESTS CONDUCTED ON SUNDAY, MONDAY AND TUESDAY. EQPT NOW IN OPERATIONAL USE. NOT FLOWN TO MAXIMUM EXTENT BECAUSE OF VARIABLE WEATHER. RESULTS OF FLIGHT TESTS SOMEWHAT SURPRISING COLON. USE OF OUR 5380 KHZ CALIB CURVE FOR 4990 CMM 5185 CMM AND 5752 GIVES TYPICAL TWO KM ERROR IN FIX. USE*

[93] Ibid, F20.

[94] Ibid, F43-44.

OF EXISTING CURVE FOR EXPERIMENTAL GEAR GIVES FIXES TYPICALLY WITHIN 500 METRES IE COMM COMPARABLE WITH PREVIOUS GEAR. THEREFORE USING PREVIOUS CALIBRATION UNTIL FURTHER TESTS CAN BE CARRIED OUT TO DETERMINE FACTORS WHICH AFFECT CALIBRATION. NOTE THAT CALIBRATIONS HERE IS VERY DIFFICULT OWING TO AVAILABILITY OF AC CMM RELATIVELY UNSATISFACTORY BEACON CMM WEATHER CMM LACK OF COMPUTING FACILITIES ETC.
FIVE. REF YOUR PARA 3 CMM INSTALLATION AND REMOVAL IS ALREADY A TWO MAN JOB. NOTE ALSO THAT LONGER FRONT CLAMP PLATES WOULD ASSIST IN INSTALLATION BY REDUCING TENDENCY TO TURN WITH BOLT. SPARE SET OF CLAMP PLATES REQUIRED IMMEDIATELY IN CASE OF LOSS.
SIX NO NEED NOW FOR SECOND C/PSU. HOWEVER WE SHOULD CONSIDER PROVIDING SET OF PLUG IN CARDS FOR RAPID REPAIR IN EVENT OF FAILURE.
SEVEN TUNING CONTROL ON C/PSU SHOULD BE FITTED WITH FINE TUNE CONTROL OR VERNIER ADJUSTMENT IF POSSIBLE.
EIGHT. AS EQUIPMENT WORKING SATISFACTORILY AND USERS HAPPY CMM HAVE MADE ARRANGEMENT TO RETURN TO CIVILISATION ON FLIGHT 9 JULY 70. REGARDS

On 5 July, Major Best sent the following signal to various agencies reference testing of the new ARDF equipment[95].



P 060030Z JUL 70
FM 547 SIG TP
ADVANCE ACTION COPY
TO RAYXWX WEAPONS SALISBURY
INFO RAMARL /AUSTFORCE VIETNAM
RAYWAA /ARMY CANBERRA
RAYAFA/ARMY MELBOURNE
BT
S E C R E T SIGS627. FOR TECHAREA ATTN PATERSON TSE . INFO CSO AFV CMM MAJ CATTANACH M18 CMM D EQPT MELBOURNE
FROM BEST .PROJECT THROUGH . YOUR X868 E 5669/3/23 NOTAL.
ONE . EQPT FLIGHT TESTED SATISFACTORILY BETWEEN 27 AND 30 JUNE . NOW IN OPERATIONAL USE SINCE 1 JULY . FULL DETAILS BEING ADVISED SEPERATELY.
TWO . WILL MODIFY C/PS4 FOR METER DISPLAY AS INDICATED .
THREE . USERS HAPPY CMM PROPOSE LEAVE COUNTRY CHARTER FLIGHT 9 JUL
BT

Figure 69: Maj Best Signal

[95] Ibid, F40 and AWM 98 R5821/1/8 Project Thorough.

Project Thorough Phase Two

On 20 July 1970, Major Cattanach (DMI) sent the following Minute to the Director, of Equipment (Army) regarding a new user requirement for future ARDF models[96]: [*Major changes highlighted*]

References: A. DMI Minute 8/21/2 of 26 May 70
B. EP Conference of 9 Jul 70

1. Resulting from decisions taken at Reference B, DMI was requested to prepare a statement of the user requirement to be followed in the construction of the future ARDF engineered models for use in the PORTER aircraft.

2. Although it was decided that no major changes to the original design would be necessary in the construction of future models, some changes would be necessary in order that maximum advantage could be taken of the enlarged working space available in the PORTER aircraft. The changes considered necessary are as follows:

a. Provision made to allow two sets of equipment to be mounted in the one aircraft. The second position, which would be identical to the present ARDF position (less DF antenna) would be used as a search position.

b. In the event of any malfunction during flight of the ARDF position, provision is required to enable the operator to manually cross connect positions in order that the search position can be used as the ARDF position.

c. Provision to be made to install a trailing wire antenna in the PORTER aircraft, to serve the two receivers in the new search position and the top receiver in the ARDF position.

d. The fitments to the base plate to enable either one or two positions to be mounted at any one time e.g. if only the ARDF position is required on any one mission, then it must be possible to mount only the ARDF position without any major installation changes being required.

e. If any common facilities are required for both positions e.g. trailing wire antenna distribution, such common facilities should be mounted on a small rack on the base plate between the two equipment positions within easy reach of both operators.

3. More detailed requirements for the above additional facilities are given in Annex A attached.

4. If possible the above amendments which will become Phase Two of this project, should be incorporated into the project during the completion of the second and third models of Phase One.

(J.G. HOOTON)
Col
DMI

20 Jul 70

Figure 70: Phase 2 User Requirement

[96] NAA: D174, E5669/3/23 Part 3. Development and manufacture of an airborne direction finding system for department of the army. F69.

ARDF Position.

a. Similar in construction and with the same facilities as is currently provided in the first WRE engineered model.

b. Consideration may however have to be given to the physical relocation of some of the present facilities in order that it is possible to allow cross connection between the ARDF position and the new search position. Some of the facilities that may be effected to allow for this flexibility are as follows:

(1) Operator Receiver selection switch.

(2) Operator Intercommunications switch.

(3) Operator Headphone output.

(4) Antenna Distribution.

Figure 71: User Requirement - ARDF Position

Search Position

a. This position to be similar in construction and with the same facilities to those presently provided for the ARDF equipment position except that the receivers are required to operate as separate receivers.

b. This position to be capable of conversion to the DF position in flight by manual cross connection by the operator in the event of any malfunction in the ARDF equipment position.

c. When operating in the search role, both receivers are to be connected to a trailing wire antenna.

d. A small removable table is required to provide writing space for the operator.

e. Common facilities to those required by the ARDF position e.g. antenna distribution should be mounted to allow easy access to both positions.

Figure 72: User Requirement - Search Position

Trailing Wire Antenna

a. One output from this antenna is required to feed the top receiver in the ARDF position. The output of this receiver is then used to feed the pen recorder to provide a passive DF system.

b. Two further outputs from this antenna are required to feed the two receivers in the search position.

c. Distribution of this one antenna to three receivers is required with the minimum of cross modulation. The distribution point to be within easy reach of the operators to allow cross connection between positions.

d. The antenna control should be motor driven to allow quick rewind and adjustments of length in flight.

e. The fitment of the antenna to the aircraft should call for minimum aircraft modification. If possible the antenna and controls should be fitted as part of the main ARDF/search position installation.

f. Easy access by the operators is required to the motor driven controls of the antenna.

Figure 73: User Requirement - Trailing Wire Antenna

Fitment to Aircraft Frame

a. The dual position and associated equipment should if possible be fitted to one base plate to allow quick installation to the aircraft.

b. The base plate should be constructed to allow either a single ARDF position or the dual position to be fitted at any one time.

c. The base plate should be designed to allow the fitment of the equipment as follows:

(1) ARDF Position - Right Hand Side of Aircraft

(2) Search Position - Left Hand Side of Aircraft

(3) ARDF Antenna - Centre of Aircraft

(4) Trailing Wire Antenna - If possible on base plate in centre of aircraft

(5) Common facilities,

e.g. Antenna Distribution - Centre of Aircraft

Figure 74: Aircraft Frame

On 11 Aug, the Director of Equipment (Army) advised WRE of the new requirement[97]:

> (Extract)
>
> *1. Reference A.* [Figure 68] *is a statement of Army requirements for the second phase of this project. Overall, the project now involves the provisioning of:-*
>
> *a. FOUR sets of ARDF equipment in racks.*
>
> *b. THREE sets of antenna and baseplates.*

Performance of New Equipment

On 12 Aug, WRE requested 547 Sig Tp to report on the performance of the new ARDF Equipment. On 31 Aug, DMI provided a summary of the 547 Sig Tp Report[98]:

> *ONE. FOLLOWING IS SUMMARY OF 547 SIG TP REPORT ON PERFORMANCE OF FIRST ENGINEERED EQUIPMENT.*
> *ALFA. ONLY MAINTENANCE REQUIRED HAS BEEN REPLACEMENT OF TWO COMPONENTS* IN TEKTRONIX CRO.
> *BRAVO. RESULTS APPEAR TO BE REASONABLY ACCURATE WHEN ALIGNED WITH OTHER SOURCES.*
> *CHARLIE. WEATHER HAS EFFECTED A NUMBER OF FLIGHTS AND THEREBY REDUCED OVERALL NUMBER OF RESULTS.*
> *DELTA. RESULTS AGAINST BEKON* [sic] *AT 4490 KHZ AT 2000 FEET HAVE GIVEN CONSTANT ERROR OF 1000 METERS ON OLD CHART.*
> *ECHO. OPERATORS STATE NEW EQUIPMENT FAR SUPERIOR TO PREVIOUS MODELS AND EASIER TO OPERATE.*
> *FOXTROT. HOPE WAS THAT METER DISPLAY WOULD* ***REDUCE RISK OF QUADS*** [99] *BUT METER DISPLAY DID NOT FUNCTION CORRECTLY AND HAS BEEN RETURNED TO WRE WITH COVERING LETTER.*
> *TWO. SPARE BENCH SEAT AND DRILLING JIG BEING PREPARED FOR DISPATCH, PLOTTING PAPER WILL BE SENT EARLIEST*

Rustrak Recorder Fault

On 3 Sep, WRE identified a fault with the Rustrak Recorder. WRE engineers subsequently modified the Rustrak.

Phase 2 Preparation

On 28 Sep, in a letter to the Director of Equipment (Army), the Deputy Director of Engineering Wing WRE acknowledged his letter dated 11 August [*see above*] and stated that WRE had commenced the preparation of cost estimates and design aspects for Phase 2[100].

During October and November there was much discussion between Army and WRE and within WRE regarding costings and testing.

---

[97] Ibid, F70.

[98] Ibid, F75.

[99] The signal on file shows REDUCE RISK OF QUADS underlined and annotated by the addressee at WRE '*vain hope*'.

[100] Ibid, F83.

Shellfest Seventy Paper

In November, Gordon Best produced a paper for Shellfest Seventy[101]. The paper contained a summary of the Australian ARDF System, operating principles, equipment description, design considerations, reliability, costs, assessment of the system and future developments[102]. A full copy of the paper is contained in Appendix 3.

Summary of Events

On 16 Nov, Gordon Best produced a Summary of Events for Project Thorough[103]. Part extract follows:

16 June 1970	-	First unit despatched to Vietnam.
25 June 1970	-	First unit arrived in Vietnam.
1 July 1970	-	First unit checked out and installed in aircraft and operational.
		Commissioning of first unit was carried out by W.R.E. Officer seconded to Army. During this period, a number of operationally desirable modifications became evident and the need for a more extensive calibration procedure was seen.
11 August 1970	-	Army stated requirements for Phase II modifications.
		DD/E replied that 1st three units would be completed to original specification and modified as a separate task.
July - Oct.1970	-	Second unit completed, design modifications incorporated.
October 1970	-	Spare Control Unit supplied to Army as back-up.
13 Nov. 1970	-	Environmental tests commenced on unit no. 2.
* Nov. 1970	-	Manufacture of No. 3 Unit expected to be completed.
		Delivery will be held pending outcome of environmental tests on Unit No. 2.
* Feb. 1971	-	Environmental tests completed on Unit No. 2.
		Extended calibration tests to be carried out by W.R.E. in conjunction with Army.
* April 1971	-	Tasks completed.

* Projected Dates

Figure 75: Part Summary of Project Thorough Events

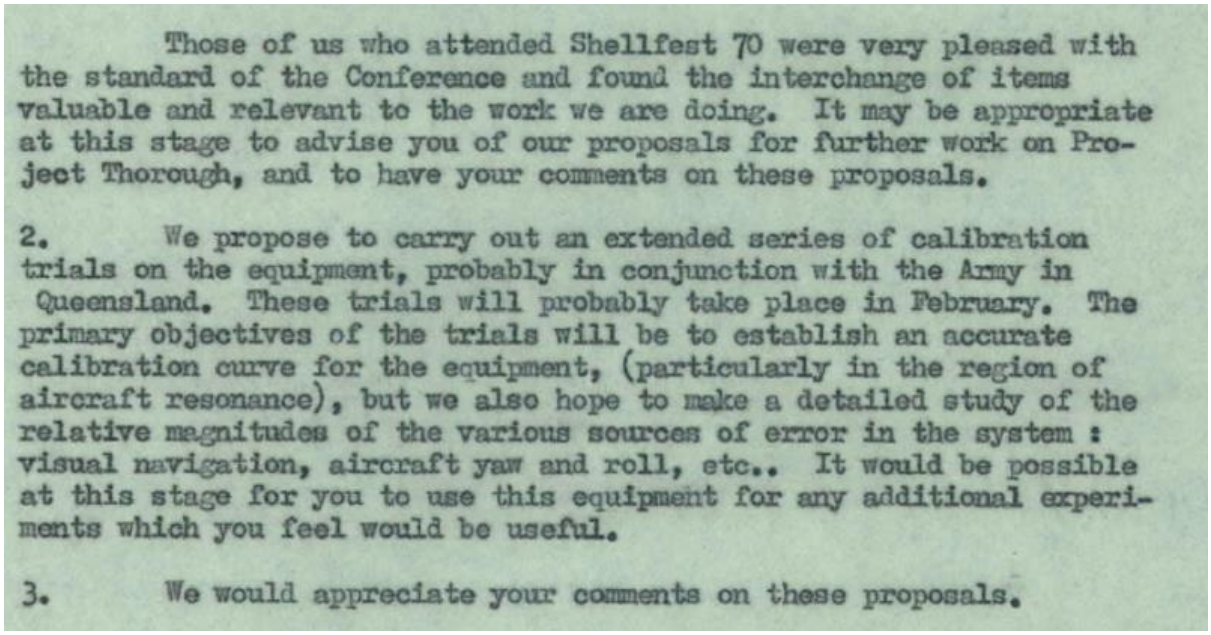
[101] Not identified.

[102] NAA: D174, E5669/3/23 Part 3. Development and manufacture of an airborne direction finding system for department of the army. F100-105.

[103] Ibid, F 39-140.

Additional Testing

On 4 Dec, the Principal Officer of the Telecommunications Systems Engineering Group, sent the following letter to the Principal officer Ionospheric Studies Group[104]



Those of us who attended Shellfest 70 were very pleased with the standard of the Conference and found the interchange of items valuable and relevant to the work we are doing. It may be appropriate at this stage to advise you of our proposals for further work on Project Thorough, and to have your comments on these proposals.

2. We propose to carry out an extended series of calibration trials on the equipment, probably in conjunction with the Army in Queensland. These trials will probably take place in February. The primary objectives of the trials will be to establish an accurate calibration curve for the equipment, (particularly in the region of aircraft resonance), but we also hope to make a detailed study of the relative magnitudes of the various sources of error in the system : visual navigation, aircraft yaw and roll, etc.. It would be possible at this stage for you to use this equipment for any additional experiments which you feel would be useful.

3. We would appreciate your comments on these proposals.

Figure 76: Additional tests in 1971

Faults on Operational Equipment

On 26 Mar 1971, 547 Sig Tp sent an urgent signal to Army Canberra, DSD, and WRE regarding faulty equipment and the need for replacement[105].

Extract:

SECRET. SIGS223 DSD FOR DP. WRE FOR PO IS GROUP. AHQ FOR MI8.
PROJECT THOROUGH. REF DEPT OF SUPPLY USER HANDBOOK (DRAFT) PARA 19 (COLUMN HOUSING ASSEMBLY)
1. THOROUGH INSTALLATION EQUIPMENT HAS BEEN SUBJECTED TO MECHANICAL WEAR. OUR HQ IS SUFFICIENTLY MOTIVATED BY URGENT OPERATIONAL REQUIREMENTS TO UNILATERALLY DEMAND REPLACEMENT UNIT (NOT DUE UNTO [sic] *1 APR 71).*
2. TO RECONSTITUTE OUR MODEL REQUEST REPLACEMENTS FOR FOLLOWING PARTS AS SOON AS POSSIBLE CLN
ALFA. ONE TRAVERSE STOP RING.
BRAVO. THE THREE RETAINING SCREWS FROM ALFA.
CHARLIE. ONE BEARING STOP SCREW (HARDENED).
DELTA. ONE INSERTION TOOL.
ECHO. ONE EXTRACTION TOOL.
3 LOCAL RAEME WORKSHOPS WORKING TONIGHT TO PRODUCE ON LATHES MILD STEEL SUBSTITUTES FOR BEARING STOP SCREW (KOMACHINED THREADED BOLT TO HALT BEARING RETAINING RING) SEE PARA 2 CHARLIE ABOVE). THIS MAY PERMIT TEMPORARY OPERATION OF EQUIPMENT FOR CRITICAL USE 0100Z TOMORROW.

[104] Ibid, F151.

[105] Ibid, F189.

On 29 Mar, 547 Sig Tp sent a follow up signal[106]:

Extract:

SECRET. SIGS226 AHQ FOR MI8. WRE FOR PO IS GROUP. DSD FOR DP.
FURTHER MY SIGS223.
ONE. THOROUGH.
ALFA. STOP SCREWS PRODUCED. THESE WITH RING AND RING SCREWS SHOULD LAST COUPLE OF WEEKS.
BRAVO. FURTHER FAULTS DEVELOPED AND TRACED TO WEAR IN WIRE LOOM. IMPROVISING WIRING BUT DOUBTFUL OF EFFECTIVENESS FOR LONG. REQUEST WIRE LOOM WITH PLUGS AFFIXED BE SENT ASP. WILL RETURN OLD LOOM ON RECEIPT. LESS URGENT BUT REPLACEMENT COLLAR (WITH KEYWAY) ALSO NEEDED.
TWO. SHORT CELL. [107]
THREE. OPS ROOM. [108]
FOUR. BRIGADIER MACDONALD TOLD BACKGROUND OF ALL PROJECTS AND UNDERSTANDS EXPERIMENTAL NATURE, PROBLEMS OF MAINT PARTS. IS ALSO AWARE NEXT THOROUGH NOT DUE UNTIL APRIL BUT WAS MOTIVATED TO REQUEST REPLACEMENT THROUGH STAFF CHANNELS.
FIVE. FURTHER DISCUSSIONS WITH HIM RESULTED IN HIS SUPPORT FOR MY REQUEST FOR WRE EXPERT TO ADVISE AND ASSIST RESTORE CELL AND COMPUTOR.
[Several lines corrupted]

On 30 March, the following signal was sent from 1 ATF to HQ AFV and Army Canberra[109]:

SECRET G0564 FOR ARMY CANBERRA INFO DMI (MI8)

PROJECT THOROUGH AND SHORT CELL
ONE. SUBJECT PROJECT INSTALLATIONS CMM IN SUPPORT 1 ATF CMM HAVE AT TIMES BEEN OF VERY CONSIDERABLE VALUE. THEY HAVE BEEN KEPT IN SERVICE CONTINUOUSLY AND HAVE RECENTLY BEEN SUBJECT TO FAILURES WHICH HAVE RENDERED THEM UNSERVICEABLE FOR UNACCEPTABLY LONG PERIODS.

TWO. STATE INSTALLATIONS AT PRESENT IS SUCH THAT ADVICE AND ASSISTANCE OF SCIENTIST CMM CURRENTLY WORKING ON THIS PROJECT IN AUSTRALIA CMM NECESSARY DUE TO CLN

ALPHA. INCREASING RATE OF FAILURES

BRAVO. ONLY ONE CORPORAL TECHNICIAN AVAILABLE WITH EXPERIENCE IN COMPUTORS [sic] *AND THE ESOTERIC EQUIPMENTS.*

CHARLIE. TECHNICIAN INABILITY TO DIAGNOSE FAULTS AND REPAIR THEM RAPIDLY ENOUGH FOR OPERATIONAL REQUIREMENTS.

DELTA. LACK OF CIRCUIT DIAGRAMS CMM FAULT FINDING AND MAINTENANCE WRITINGS.

THREE. TO ALLEVIATE PROBLEMS ENUMERATED IN THE TWO ABOVE REQUEST THAT TWO SCIENTISTS FROM WRE BE ATTACHED TO 1ATF AS SOON AS POSSIBLE UNTIL INSTALLATIONS ARE RESTORED TO SATISFACTORY STATUS AND REPAIR AMD MAINTENANCE SYSTEMS UPDATED.

FOUR. A SECOND PROJECT THOROUGH EQUIPMENT IS REQUIRED TO BACK UP EXISTING EQUIPMENT.

[106] Ibid, F190.

[107] Many faults listed for Short Cell (SSL).

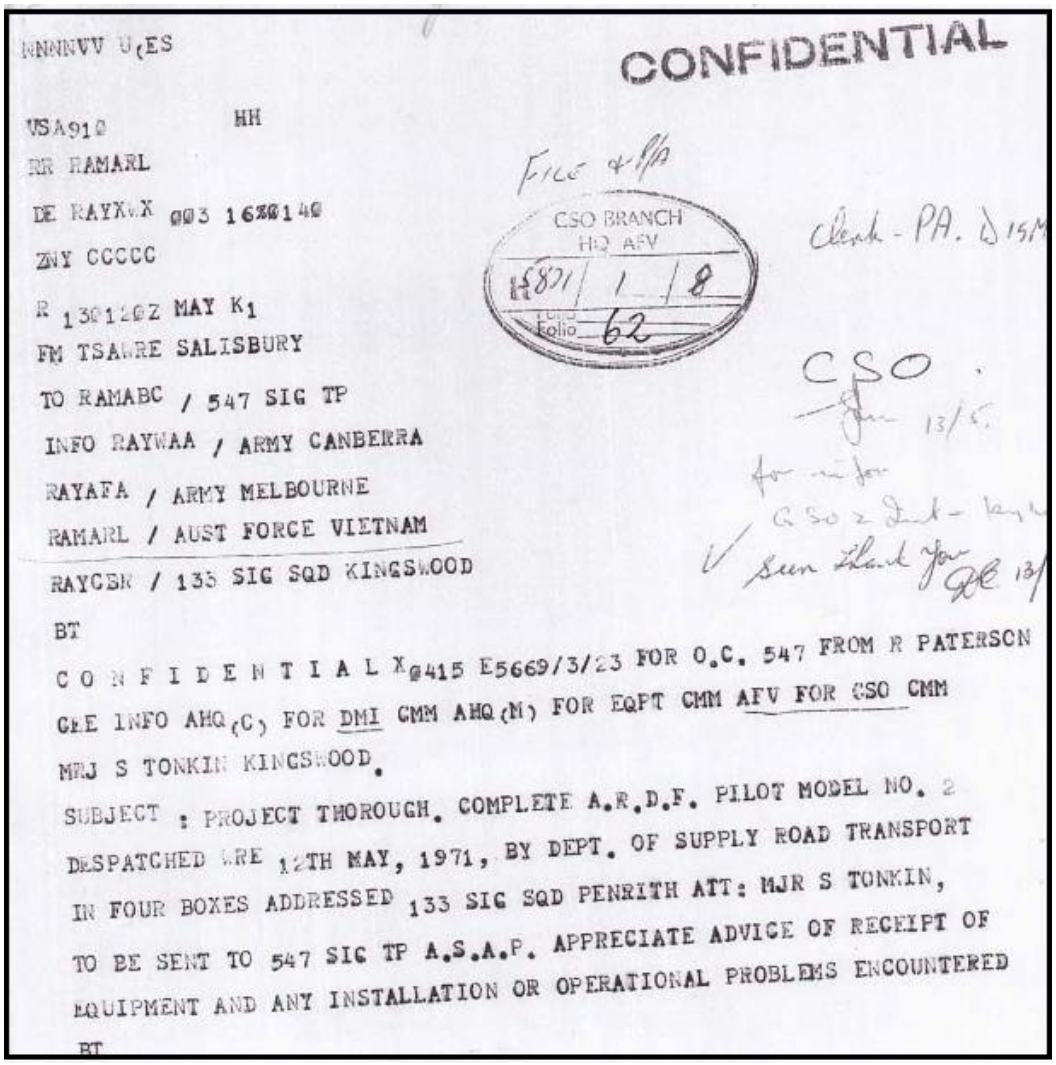
[108] Several receivers faulty but no threat to Ops.

[109] AWM98 R5821/1/8.

Subsequently the scientists arrived to fix the problems and later a second system was received.

Additional ARDF Equipment

On 13 May, the Troop was advised that a complete ARDF Model, Pilot Model No 2, had been despatched from WRE for installation in the aircraft[110].



CONFIDENTIAL

VSA910 HH
RR RAMARL
DE RAYXXX 003 16X0140
ZNY CCCCC
R 130120Z MAY K1
FM TSAWRE SALISBURY
TO RAMABC / 547 SIG TP
INFO RAYWAA / ARMY CANBERRA
RAYAFA / ARMY MELBOURNE
RAMARL / AUST FORCE VIETNAM
RAYCBR / 133 SIG SQD KINGSWOOD
BT
C O N F I D E N T I A L X0415 E5669/3/23 FOR O.C. 547 FROM R PATERSON
CLE INFO AHQ(C) FOR DMI CMM AHQ(M) FOR EQPT CMM AFV FOR CSO CMM
MRJ S TONKIN KINGSWOOD.
SUBJECT : PROJECT THOROUGH. COMPLETE A.R.D.F. PILOT MODEL NO. 2
DESPATCHED WRE 12TH MAY, 1971, BY DEPT. OF SUPPLY ROAD TRANSPORT
IN FOUR BOXES ADDRESSED 133 SIG SQD PENRITH ATT: MJR S TONKIN,
TO BE SENT TO 547 SIG TP A.S.A.P. APPRECIATE ADVICE OF RECEIPT OF
EQUIPMENT AND ANY INSTALLATION OR OPERATIONAL PROBLEMS ENCOUNTERED
BT

CSO BRANCH HQ AFV R5821/1/8 Folio 62

Figure 77: WRE Signal

Engineered System

As mentioned above, in May 1971, an engineered ARDF system was delivered to the Troop. The new system was installed into a second Porter aircraft for testing, and post trials, remained in the aircraft. The prototype system remained in the initial aircraft and due to increased VC/NVA activity it was decided that both aircraft would remain available for tasking. The use of two aircraft continued until departure from SVN.

[110] AWM 98 R5821/1/8.

Project Update

On 21 July, the Deputy Director of Engineering sent an internal letter to the Controller of Research and Development WRE on the progress of Project Thorough[111]:

Extracts:

> *Phase I of this project is nearing completion, although a as indicated in letter my to you dated 17th November, 1970, we are having difficulties in keeping up with the ever increasing demands of Army for changes and improvements in the performance of the equipment.*
>
> *This letter has not been answered specifically instead it has*
> *Been dealt with progressively by a series of letters, and meetings each covering the different aspects raised. However, as indicated above it been difficult to come to grips with such requirements that have kept changing which is probably to be expected in an experimental equipment engineered to the higher standards required for field use by the Services and evolving with operational experience.*
>
> *One set of equipment has been completely modified and despatched by Army to Vietnam and the remaining set is undergoing modification in our Workshops and is 95 percent complete and should be available for despatch to Army by the of this month. The other equipment currently in use in Vietnam will be returned for modification when they have the replacements to hand. Action is still outstanding and is of some concern as we have not yet been able to determine what characteristics of the aircraft and terrain are causing unexplained changes in calibration. When we have staff available to determine a meaningful trials programme aimed at solving this problem Army will be advised of the assistance needed in the provision of trials aircraft.*
>
> *It has not been possible to allocate much effort to this phase of the work to date due to staff limitations nor has it been possible to agree with Army a detailed specification for this work. There could be some difficulty in carrying out this experimental work to the rigid engineering requirements of Director or Equipment which are more applicable to a production equipment. It is probably appropriate to arrange a meeting with Army in the near future to resolve a mutually suitable method of work on such projects.*

Relocation of Assets

In August 1971, news of the possible withdrawal of Australian troops was received. After many discussions with senior officers it was recommended that the Troop remain in SVN and be one of the last to leave. Subsequently, the Troop was to relocate to Vung Tau with the remaining forces, and ARDF operations operate out of the Vung Tau Airfield until the Troop departed Vietnam.

[111] NAA: D174, E5669/3/23 Part 3. Development and manufacture of an airborne direction finding system for department of the army. F239.

Probable cancellation of Phase 2

The WRE File contained the following handwritten note dated 26 August[112]:

> *As a result of meeting at DSD on 24/8 it is considered that we should not proceed with Phase 2 of Thorough. Army (ADE) may of course wish to but his is their decision & they would in that case have to find other resources to do it. We will discuss further after the progress meeting on the project & then be in a posn to write to C/R&D recommending future actions.*

1 September Meeting

On 4 November, the Superintendent CEE Division of WRE advised internal addressees and Army Canberra the results of a Meeting with Army held at WRE on 1 September[113]:

> *FOLLOWING IS CURRENT POSITION OF PROJECT THOROUGH.*
>
> *A MEETING WAS HELD AT WRE ON 1 SEPTEMBER 1971 WITH REPRESENTATIVES OF DEPARTMENT OF ARMY, To REVIEW PROJECT THOROUGH PROGRESS AND THE FUTURE ARMY*
> *REQUIREMENTS FOR ARDF EQUIPMENT IN VIEW OF THE IMPENDING WITHDRAWAL OF AUSTRALIAN FORCES FROM VIETNAM.*
>
> *THE ARMY ADVISED THAT PHASE 2 OF THE PROJECT AS ORIGINALLY PLANNED WAS NO LONGER REQUIRED. THIS PHASE OF THE PROJECT WAS OUTLINED IN DOCUMENT RD71 SECTION 3 TASK NO.70/D AND WAS TO HAVE THE DEVELOPMENT, MANUFACTURE AND COMMISSIONING OF THE TWO-OPERATOR SYSTEM, INCLUDING ONE ADDITIONAL RACK OF EQUIPMENT, A NEW BASEPLATE, SWITCHING AND ANTENNA DISTRIBUTION CIRCUITS AND A SUITABLE OMNI-DIRECTIONAL ANTENNA FOR FIELD STRENGTH MEASUREMENTS AND FOR SIGNAL SEARCH. THE EQUIPMENT WAS TO BE COMPATIBLE WITH THE (PHASE 1) SO THAT EQUIPMENT RACKS AND AERIAL COLUMNS COULD BE INTERCHANGED BETWEEN SINGLE OR TWO-OPERATOR SYSTEMS. EITHER ARRANGEMENT WOULD USE THE SAME AIRCRAFT MOUNTING POINTS.*
>
> *THE TOTAL COST WAS ESTIMATED AT $46,469 AND THE TOTAL EFFORT REQUIRED WAS ESTIMATED AT 750 MAN-DAYS.*
>
> *DUE TO CHANGED CIRCUMSTANCES, THE ARMY NO LONGER*
> *REQUIRES THE COMPLETE 2-OPERATOR SYSTEM DESCRIBED ABOVE. SINGLE-OPERATOR "PHASE 1" EQUIPMENTS ARE TO BE COMPLETED AND FORMALLY ACCEPTED BY THE ARMY AS ORIGINALLY PLANNED. HOWEVER, THE FIELD STRENGTH MEASURING FACILITY WHICH WAS PREVIOUSLY SPECIFIED AS PART OF PHASE 2 IS STILL REQUIRED. IT WILL BE INCORPORATED IN THE THREE SINGLE-OPERATOR PHASE 1 EQUIPMENTS. BETTER CALIBRATION DATA FOR THE ARDF SYSTEM IS ALSO STILL REQUIRED.*
>
> *THE FOLLOWING TENTATIVE PROGRAMME FOR FINALISING PROJECT THOROUGH WAS AGREED TO. FOR CONVENIENCE, IT WAS DECIDED TO BROADLY CLASSIFY REMAINING WORK AS FOLLOWS:*
>
> *(A) PHASE 1 (PART 1); COMPLETION, AIS INSPECTION AND ACCEPTANCE OF THREE EQUIPMENTS.*
>
> *TWO EQUIPMENTS ARE IN OPERATIONAL USE WITH THE ARMY AND THE THIRD IS IN WRE WORKSHOPS AWAITING FORMAL ACCEPTANCE BY THE ARMY.*
>
> *MANHOURS OF PROFESSIONAL EFFORT. THE PROJECT WILL BE REVIEWED WITH THE ARMY AS EXPENDITURE APPROACHES THE ABOVE ESTIMATE TO ASSESS ACHIEVEMENTS AND THE LIKELIHOOD OF SUCCESSFULLY DEVELOPING A SUITABLE SYSTEM. IF IT IS UNLIKELY THAT A SYSTEM CAN BE DEVELOPED NO FURTHER EXPENDITURE WILL BE MADE. IF THE INVESTIGATION INDICATES THAT A SUITABLE SYSTEM COULD BE DEVELOPED A NEW TASK*

[112] Ibid, F252.

[113] NAA: D174, E5669/3/23 Part 4. Development and manufacture of an airborne direction finding system for department of the army. F2-5.

COVERING THE DEVELOPMENT OF THE FIELD STRENGTH MEASURING SYSTEM WILL DE PREPARED AND SUBMITTED FOR APPROVAL.

IF THE ABOVE PROPOSALS ARE ADOPTED, PHASE 1 OF THE PROJECT WILL BE VIRTUALLY UNCHANGED AND THE EXISTING COST AND MANHOUR ESTIMATES WILL BE UNAFFECTED.

PHASE 2 WILL BE REDUCED TO AN INVESTIGATION AND FIELD EVALUATION WITH THE POSSIBILITY OF LIMITED MANUFACTURE DEPENDING ON THE RESULTS OF TRIALS.

PRIORITY ON BOTH PHASES 1 AND 2 WILL BE REDUCED BECAUSE OF CHANGED OPERATIONAL REQUIREMENTS.

A TECHNICAL COST PLAN FOR PROPOSED PHASE 2 WILL BE FORWARDED SHORTLY FOR YOUR APPROVAL.

ARDF EQUIPMENT MAINTENANCE

Technicians

Throughout its use in SVN, and the high priority placed on its use by 1 ATF Staff, maintenance of the equipment became a major issue. Normally, there was only one system in-country and the equipment could not be removed from the aircraft for regular detailed servicing. In the majority of times when the system developed a fault, unit technicians had to try and rectify the problem while the equipment remained in the aircraft.
Technicians were given no training on the equipment before arriving in SVN. There were no detailed service plans or spare parts until 1971. Some maintenance manuals were available for the individual pieces of equipment but no detailed manuals or drawings of the system, and limited spare parts. Technicians had to rely on the experience and knowledge passed on by the previous technician that had been gained by finding and fixing faults. Fortunately many of the technicians kept notes on what they found and how they fixed the problem. If required, and suitable, spare parts were cannibalised from other equipment. Eventually the technical staff were able to acquire sufficient spare parts to cover most of the common equipment failures.

A senior technician[114] later wrote:

> *For most of the operational life of ARDF, the unit lacked critical test equipment with which to effectively maintain the Racal RA-217 receivers (specifically a Rhode and Schwarz Polyskop for alignment of the Wadley Loop bandpass filters). It required some creative improvisation on the part of the technicians to ensure that effective alternate procedures were developed and put in place to maintain the receivers to specification.*

Not enough plaudits can be given to the technicians in how they approached their duties and kept the aircraft flying. The Troop only had an establishment of two technicians: one Sergeant and one Corporal[115]. It was extremely fortunate that the majority of them had had previous experience with Sigint equipment. All technicians worked extensive hours and were always on call.

[114] Garth Brown memoirs.

[115] In 1971 a second technician was added.

FLIGHT PERSONNEL

ARDF Operators

Apart from the Sergeant in charge of ARDF operations, operators assigned to ARDF duties were all Op Sigs who had been in-country for a few months and conversant with most of the targets. There were no training manuals, no training equipment and insufficient air hours to fly training missions. All training had to be conducted on the job. Once trained in ARDF Operations, an operator could expect to remain on ARDF duties while he remained in-country.

In general terms an operator was expected to have:

- **Liaison Skills**. A high level of liaison with pilots was necessary. A lot of interaction between the pilot and operator was required prior to, and during a mission, and when communicating with US counterparts.

- **Map Reading**. A high degree of map reading skills to accurately relate the ground to a map from the air.

- **Hand/Eye Coordination**. ARDF operators had to have excellent hand/eye coordination to ensure maximum accuracy in operating the ARDF equipment.

- **Used to Working in Cramped Conditions**. Operators had to contend with cramped, noisy conditions, particularly in the Cessna.

- **Flying Hours**. ARDF operators were not governed by the amount of flying hours that could be flown during the month like Pilots. Operators had to be available when required.

- **Air Sickness**. Contend with air sickness from flying in severe turbulence at low levels.

- **Operating Skills**. The ARDF operator needed to have exceptional operating skills. At times he had to be able to copy a transmission, conduct DF and report to the ground station simultaneously.

- **Target Knowledge.** The operator had to maintain an intimate knowledge of the targets and be aware of their previous locations.

- **Psychological Warfare.** If on a run, a target stopped transmitting during the passing of traffic, the ARDF operator could assumed that it was due to the presence of the aircraft (VC/NVA knew of the existence of US ARDF aircraft). At times the operator would drop propaganda leaflets, issued by 1ATF Psychology Unit, to disguise the real task of the aircraft. This ruse was usually successful.

Allocation of Duties to ARDF Personnel

Missions or sorties were allocated to the operators by the Sergeant IC of the ARDF Section. Normally sorties were allocated on a rotational basis between the available operators, and when not on flying duties or sleeping, they were required to either man the ARDF Control (DSU[116]), carry out administrative duties, or assist in the Set Room. When an ARDF operator went on R&R or was sick, his duties were shared among the other two personnel. No additional ARDF trained operators were available.

ARDF Control/DSU Position

The DSU control position contained two VHF nets: one to communicate with all the supporting US ARDF Aircraft in the area, and the second to communicate to the Troop's ARDF Aircraft. US Aircraft usually operated between the hours of 0600 to 2400 and the position had to be fully manned at these times.

Both nets were covered by secure voice equipment (KY-8). One Time Pads (OTP) were used as backup when there were secure voice breakdowns.

All traffic from the US Aircraft had to be forwarded by signal to the US Sigint Units through the Troop's Communications Centre.

The link to the Troop's ARDF aircraft was used for safety, target guidance, both to and from the set room, forwarding of fix information from the aircraft when needed, and general flight information.

A general communications receiver was also installed in the operators console to enable the operator to tune to any given task and provide guidance to/from the ARDF operator if required, and to conduct general search during times of inactivity.

Photographs of the ARDF control area and console are shown below:

[116] Direct Support Unit.

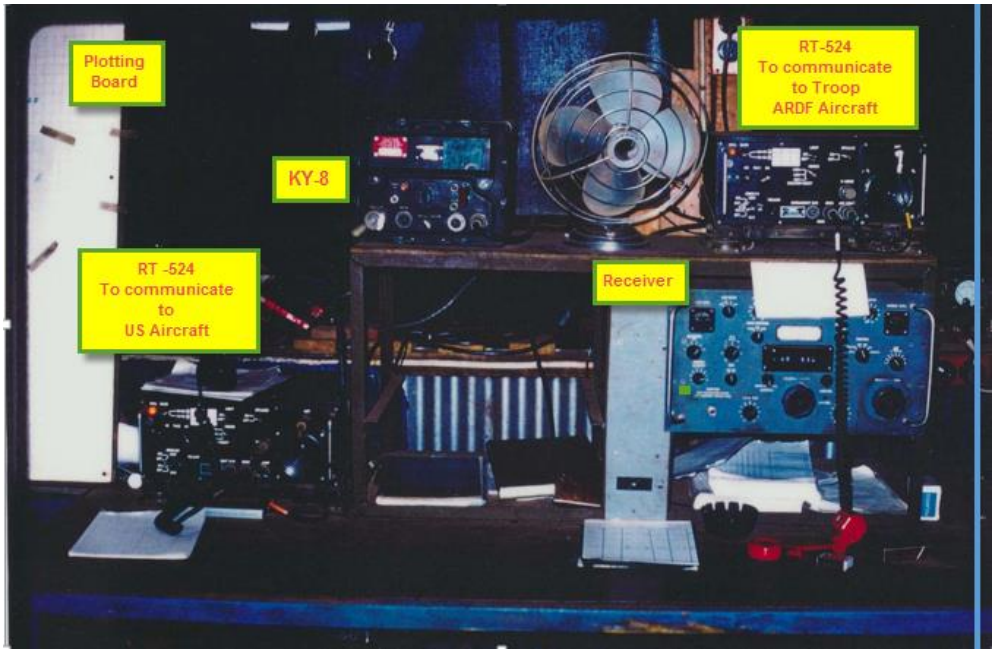


Figure 78: 547 Sig Tp ARDF control console

Figure 79: ARDF Control Area with plotting board Jan 1969

Pilots

Normally, there were four fixed wing pilots in 161 Recce Flt. The pilots who flew the ARDF mission had to hold the necessary security clearances and special briefings, as there had to be close liaison between the operator and pilot. At times this security requirement caused a delay on pilots receiving official clearance, and placed an additional load on those pilots already cleared.

In the aviation world, the mission of the fixed wing aircraft became known as 'shush' missions. This came about when the CO of 161 Recce Flt was asked by a visiting senior officer what the Cessna with all the electronic equipment was used for. His response was "Shush, we can't talk about it".

As an aside, no aircraft maintainers or operations staff in 161 Recce Flt were formally briefed on the role of the aircraft. However, they were aware that the aircraft had an important role, emphasised by the Commander 1 ATF, and always placed a high priority on the tasking, operation and maintenance of the aircraft.

The following table lists the 161 Recce Flt fixed wing pilots that flew ARDF missions[117]:

Date Arrived	Date Departed	Rank	Family Name	Given Name	Remarks
29-Jul-66	01-Aug-67	MAJ	Doyle	Lawrence	OC DFC
22-Sep-66	15-Sep-67	CAPT	Wright	John	
22-Sep-66	27-Sep-67	2LT	Guivarra	Thomas	
21-Apr-67	9-Jan-68	LT	Peacock	Kevin	
21-Apr-67	23-Apr-68	2LT	McFerran	David	
18-Jul-67	23-May-68	MAJ	Constable	George	OC
1-Sep-67	6-Sep-68	CAPT	Forrest	Bernie	
1-Sep-67	3-Sep-68	CAPT	Coggan[118]	John	DFC
08-Jan-68	17-Dec-68	2LT	Tizzard	Stephen	
23-Apr-68	10-Dec-68	2LT	Tippet	Richard	
14-May-68	11-May-69	2LT	Gerard	David	
21-May-68	15-May-69	2LT	Muir	Peter	
10-Jun-68	18-Jun-69	MAJ	Benson	Henry	OC DFC
26-Aug-68	17-Dec-68	CAPT	Donald	Barry	See below
07-May-69	30-Apr-70	2LT	Sedgers	Anthony	
07-May-69	14-May-70	2LT	Driver	Errol	
10-Jun-69	11-Jun-70	MAJ	Hill-Smith	Graeme	OC DFC
11-Jun-69	03-Dec-69	CAPT	Donald	Barry	KIA DSM[119]

[117] Note: It has not been confirmed if all the fixed wing pilots in 1966/67 flew ARDF missions. Compiled by various records at the AWM and ARDF Operator's memories.

[118] Primarily a helicopter pilot but flew a few ARDF missions in Jan/Feb 68.

[119] On 3rd June 1998, a Vietnam "End of War List" was announced by the Australian Government, in that *"End of War List" Barry Donald was awarded the Distinguished Service Medal (Posthumously).*

Date Arrived	Date Departed	Rank	Family Name	Given Name	Remarks
15-Jul-69	16-Jul-70	CAPT	Wark	Trevor	
17-Nov-69	19-Nov-70	2LT	Aird	Damien	
10-Dec-69	10-Dec-70	CAPT	Smith	Robert	
29-Apr-70	01-May-71	2LT	Coffey	Dennis	
12-Aug-70	05-Aug-71	2LT	Sinnott	Ian	
03-Feb-71	23-Dec-71	MAJ	Harden	Neil	OC MID
21-Jul-71	23-Dec-71	2LT	Marsden	Charles	

Monthly Flying Hours

The following table shows the actual ARDF flying hours for the period December 1969 to October 1971[120].

Year	Month	Aircraft	Daylight Flying		Night Flying		Remarks
			Hours	Sorties	Hours	Sorties	
1969	December	Cessna	143.40	62	2.25	1	
1970	January	Cessna	129.00	54	2.05	1	
		Porter	36.15	18			
	February	Porter	99.20	50			
	March						Unknown
	April	Porter	136.10	59			
	May	Porter	140.30	64			
	June	Porter	139.55	72			
	July	Porter	101.40	58			
	August	Porter	118.55	57			
	September	Porter	118.30	60			
	October	Porter	117.55	57			
	November	Porter	147.35	62			
	December	Porter	145.30	62			
1971	January	Porter	147.00	57			
	February	Porter	130.05	57			
	March	Porter	160.40	72			
	April	Porter	165.40	83			
	May	Porter	165.45	80			
	June	Porter	181.05	100			A 2nd aircraft was fitted with equipment
	July	Porter	171.00	93	1.30	1	
	August	Porter	214.05	116	.40	1	
	September	Porter	318.05	165	1.00	1	Operations now flying out of Vung Tau
	October	Porter	312.00	156			

[120] Extract from AWM 289 R733/1/4 161 Indep Recce Flt Flying Hours Monthly Return.

The following table was compiled from information in documents received from ASD in August 2015.

Year	Month	Flying hours	Total Bearings	Good <1000mts	Fair 1-2000Mts	Poor >2000 Mts	Cut	Missions Lost	Remarks
1967	Oct	97	56	16	28	12			Plus 15 hrs night
	Nov	73	57	14	36	7		2	Plus 2 hrs night
	Dec	107	90	19	48	15	8	5	Plus 8 hrs night
	Total	**277**	**203**	**49**	**112**	**34**	**8**	**7**	
1968	Jan	90	119	19	69	17	14	3	Plus 8 hrs night
	Feb	115	124	17	76	13	18	2	
	Mar	84	66	4	43	5	14	4	
	Apr	96	118	17	71	10	20	1	
	May	122	158	26	87	7	38	1	
	Jun	92	120	20	77	6	17	2	
	Jul	105	100	22	57	-	21	7	
	Aug	130	125	3	76	16	30	8	
	Sep	116	112	7	58	5	42	9	
	Oct	134	141	19	98	4	20	?	
	Nov	107	120	19	95	1	5	?	
	Dec	144	165	24	121	6	14		Inc 3.30 Trg
	Total	**1335**	**1468**	**197**	**928**	**90**	**253**	**37**	
1969	Jan	146	161	38	114	1	8	4	
	Feb	134	179	40	114	6	19	1	
	Mar	132	171	24	118	5	24	6	
	Apr	147	112	4	26	12	30	9	
	May	126.5	68	2	51	2	13	9	plus 5 hrs training
	Jun	132.5	147	5	102	15	25	15	
	Jul	122.75	31	3	20	3	5	11	plus 77.5 hrs on equip maint
	Aug	123.5	36	2	24	6	4	21	
	Sep	137.15	28	6	14	5	3	24	Incl 10.55 hrs training
	Oct	148.2	61	23	22	10	6	13	
	Nov	134.1	76	13	53	3	7	14	plus 4.3 hrs training
	Dec	141.35	58	13	35	2	10	15	
	Total	**1625.05**	**1128**	**173**	**693**	**70**		**142**	
1970	Jan	138	52	6	35	4	7	6	Changeover to Porter plus 18 hrs trg
	Feb	94.4	42	10	20	7	5	20	
	Mar	133.25	54	26	17	2	9	6	
	Apr	131.15	66	25	32	1	8	4	Incl 2.5 hrs training
	May	141.25	62	27	30		5	3	

Year	Month	Flying hours	Total Bearings	Good <1000mts	Fair 1-2000Mts	Poor >2000 Mts	Cut	Missions Lost	Remarks
	Jun	147.55	63	21	36		6	19	Incl Reduced due to weather
	Jul	100	48	18	27		3	30	Incl Reduced due to weather
	Aug	120.5	63	24	34		5	18	Incl Reduced due to weather
	Sep	114.05	85	36	46		3	16	Incl Reduced due to weather
	Oct	121.1	76	28	46		2	16	Incl Reduced due to weather
	Nov	146.35	101	22	74		5	3	
	Dec	140.05	128	36	80	1	11	5	
	Total	**1527.65**	**840**	**279**	**477**	**15**	**69**	**146**	
1971	Jan	135	126	42	76		8	8	
	Feb	119.35	78	30	43		5	9	
	Mar	155.25	108	39	64		5	9	
	Apr	168.2	91	25	56		10	4	
	May	159.4	101	14	83		4	10	
	Jun	178.55	72	14	44		14	16	Incl Reduced due to weather
	Jul	173.15	35	7	24		4	5	
	Aug		77	24	32	11	10	5	Two aircraft at times
	Sep		116	23	64	17	12	5	Two aircraft at times
	Oct		65	10	36	15	4	9	Two aircraft at times
	Nov		108	24	47	23	14	7	
	Total		**977**	**252**	**569**	**66**	**90**	**87**	

Appendixes:

1. Technical Memorandum CPD (T) 169.

2. Draft Report on Project Thorough.

3. Shellfest Seventy Report on Project Thorough.