

**UNITED STATES AIRFORCE  
AIRBORNE RADIO DIRECTION FINDING SYSTEM  
SOUTH VIETNAM 1966**

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*The US Airforce (USAF) 6994th Security Squadron provided ARDF support to the Troop when they were active in, or close to, the 1<sup>st</sup> Australian Task Force (1ATF) Area of Operations (AO).*

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*This Annex is a compilation of data taken from documents now released by the US Air Force and available on the EC-47 History web site plus additional valuable assistance from Joe Martin.*

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## Prime Source Documents

### Project CHECO South East Asia Report<sup>1</sup>:

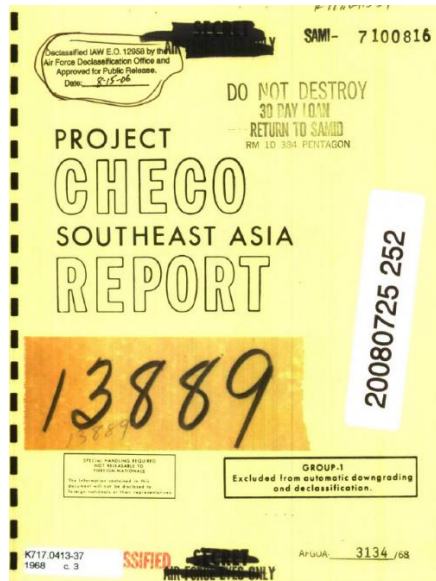


Figure 1: CHECO Document

### History of the 6994<sup>th</sup> Security Squadron 1 July – 31 December 1966

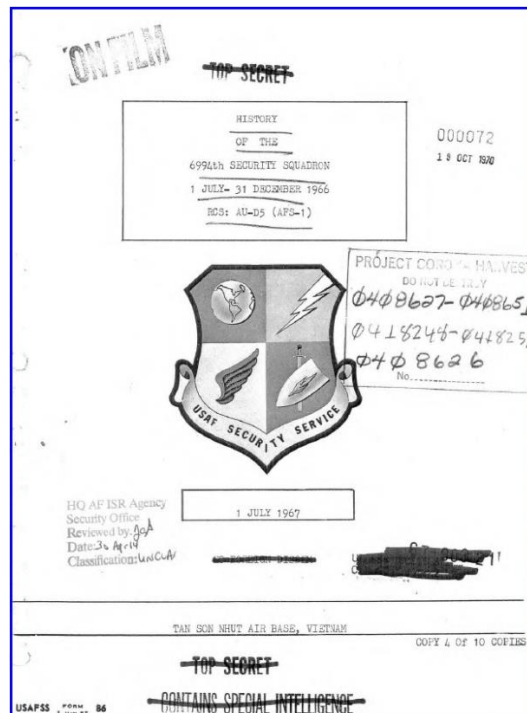


Figure 2: Cover Page<sup>2</sup>

<sup>1</sup> [www.dtic.mil/dtic/tr/fulltext/u2/a486464.pdf](http://www.dtic.mil/dtic/tr/fulltext/u2/a486464.pdf)

<sup>2</sup> USAFSS History of the 6994<sup>th</sup> Security Squadron 1 July – 31 December 1966 RCS: AU-D5 (AFS-1) dated 1 July 1967

## Web Page

There are two web pages devoted to the 6994<sup>th</sup> Security Squadron and the EC-47 Project:



Figure 3: 6994<sup>th</sup> Web page<sup>3</sup>:

<sup>3</sup> <http://6994th.com/>



The banner at the top of the page features three main elements: on the left, the EC-47 History Site logo with the text 'Originated in 1997'; in the center, the 50th Anniversary Commemorative Partner logo for the United States of America Vietnam War; and on the right, a photograph of an EC-47 aircraft flying over a large American flag.

What's New ?

Guestbook

Vietnam War Commemoration

ARDF History Exhibit

History of the EC-47

Tell your EC-47 story !

Odds 'n ends

In Memoriam

Photo Galleries

The EC-47 Newsletter

## The EC-47 History Site - A Legacy Preserved



All viewers are invited and encouraged to sign our website **Guestbook**. It is available as the second item on the main Menu. The **Guestbook** is interactive and does require ec47.com Admin review of all entries before they are visible on-line. This service is checked frequently and you should expect your comments to be updated within a few hours of entry. Please sign-in and let our viewers know about your experiences and interests in the EC-47 program.

Let us know how this feature works for you at:  
[info@ec47.com](mailto:info@ec47.com)

### Welcome to the **NEW** EC-47 Website!

**Our Mission:** To compile, preserve, and disseminate a complete and accurate history of the EC-47 aircraft and its role in the Vietnam War, based on contemporary squadron histories and other official documents and enhanced by contributions from the veterans who flew and maintained the aircraft.

This website is an ongoing project.  
Please check back frequently for updates.

[Click Here](#)  
To Visit The Original J.C. Wheeler Archive Site



Logos for the 362nd and 699th Squadrons are displayed at the bottom left. The 362nd logo includes the text 'This Site Made Possible by a Grant from the Freedom Through Vigilance Association' and the website 'www.362ndnews.com'. The 699th logo includes the website 'www.6994th.com'.

Figure 4: EC-47 History Web Page<sup>4</sup>

<sup>4</sup> <http://ec47.com/>

## 6994<sup>th</sup> SECURITY SQUADRON

### Background

At the earliest stages of the U.S. build up in Vietnam, a system was needed to locate Viet Cong and North Vietnamese radio transmitters. Conventional ground-based Radio Direction Finding (RDF) methods proved difficult in attempting to locate low-powered enemy transmitters. The solution was Airborne Radio Direction Finding (ARDF) by Army and Air Force aircraft.

The aircraft selected by the Air Force for its ARDF effort was the venerable C-47. The C-47 was a derivative of the DC-3 commercial airliner developed by the Douglas Aircraft Company. First built in the 1930's, the C-47 (Gooney Bird) distinguished itself as a transport in World War II, the Berlin Airlift, and the Korean War.

Prior to being sent to Southeast Asia, the planes had to be equipped with a multitude of electronic components so as to fulfil their mission. Thus was born the EC-47. In 1966 squadrons were formed at Tan Son Nhut Air Base, Nha Trang Air Base, and Pleiku Air Base to conduct EC-47 ARDF operations. The flight crews consisting of the pilots, co-pilots, navigators and flight mechanics were assigned to the 360th, 361st, and 362nd Tactical Electronic Warfare Squadrons, respectively. The mission specialists, consisting of Morse Radio Intercept Operators (Ditty-Bops), linguists, communications analysts, and equipment repairmen were assigned to the 6994th Security Squadron and its detachments.<sup>5</sup>

Extract from the History of the 6994<sup>th</sup> Security Squadron<sup>6</sup>:

### Mission

*The specific mission of the 6994th Security Squadron was to perform the United States Air Force Security Service (USAFSS) role in the Airborne Direction Finding program in Southeast Asia. The unit accomplished its mission through the resources of Projects Phyllis Ann, Drill Press and Hawkeye. Through these facilities the unit provided:*

- (1) Direct COMINT support to combat activities by pinpointing the location of Viet Cong targets, and passing the information to Direct Support Units (DSU).*
- (2) ARDF of Viet Cong targets for the United States Security Agency (ASA) units in support of exploitation activities, and*
- (3) Augmentation of ASA intercept facilities through the ARDF acquisition equipment and the Drill Press airborne collection platforms.*

*The mission of the organization was unique. Its entire function was that of a collection activity, operating in support of Army, Navy and Marine SIGINT activities. The organization had no processing responsibility and played only a passing role in*

<sup>5</sup> Extract from: <http://www.6994th.com/mission.html>

<sup>6</sup> USAFSS History of the 6994<sup>th</sup> Security Squadron 1 July – 31 December 1966 RCS: AU-D5 (AFS-1) dated 1 July 1967

reporting.

#### Organization

*The 6994th Security Squadron was located at Tan Son Nhut AB, Vietnam. The squadron was directly subordinate to the 6922d Security Wing Located at Clark AB Philippines. Units subordinate to the Squadron were its two detachments: Detachment 1, located at Nha Trang; and Detachment 2, Located at Pleiku. Operationally, the unit was subordinate to Headquarters, Seventh Air Force, also located at Tan Nhut. However, due to its close tactical support mission to both ground and air activities, operational control was normally accepted as being exercised by Military Assistance Command, Vietnam (MACV-J2).*

#### **Aircraft**

As previously mentioned, the Squadron operated out of Tan Son Nhut airport, Saigon, and flew EC-47 (DC3) Aircraft.



Figure 5: EC-47 (DC-3) Aircraft<sup>7</sup>



Figure 6: EC-47<sup>8</sup>

<sup>7</sup> Extract from: <http://www.6994th.com/mission.html>

<sup>8</sup> Ibid





This is a front shot of the real McCoy, EC-47 979. It was no surprise to see many of the old Electric Goons surrounded by TEWS maintenance guys. They did a helluva job keeping these old monsters aloft.

Figure 7: EC-47<sup>9</sup>



Figure 8: 6994th Security Squadron Plaque<sup>10</sup>

<sup>9</sup> <http://www.talkingproud.us/Military/Det3EC47s/Det3EC47s/Det3EC47sAircraft.html>

<sup>10</sup> Ibid.

## Types of Sigint Aircraft

Initially three types of Sigint aircraft operated in South Vietnam: codenamed Hawkeye, Drill Press and Phyllis Ann.<sup>11</sup>

### Hawkeye:

The single Hawkeye aircraft was equipped with a prototype ARDF system, and contained no acquisition/collection equipment. The aircraft flew its last mission on 9 July 1966. The equipment was subsequently stripped from the airframe and the aircraft returned to the United States during early August.<sup>12</sup>

### Drill Press:

Initially two Drill Press aircraft<sup>13</sup> were fitted out for pure intercept. The following sketch shows the aircraft intercept positions:

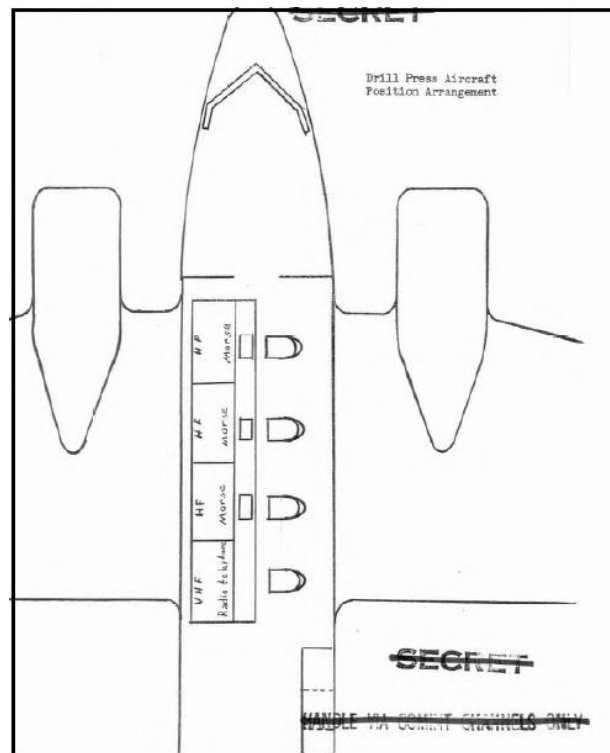


Figure 9: Drill Press Aircraft<sup>14</sup>

<sup>11</sup> Email from Joe Martin to to Bob Hartley 3 Mar 16. A total of 69 aircraft were converted to EC-47 configuration. One of these crash-landed in Alaska on the way over. Thirty-three EC-47s were turned over to the VNAF in 1972-72, operated by the specially established 718th Reconnaissance Sqn (although they now like to call it 718th TEWS) The Vietnamese "back enders" were ARVN troops assigned to Unit 17 of J7, Vietnamese Joint General Staff. The more senior of these guys had been at it since the French days and needed only to be taught how to run the ARDF equipment. I was one of the dozen or so 6994th troops who, at one time or another, provided the instruction, both ground and airborne.

<sup>12</sup> 6994 Sqn TRINE SAVIN History.pdf

<sup>13</sup> In an email to Bob Hartley in February 2016, Joe Martin recalled: HAWKEYE was, as noted, the prototype C-47 ARDF platform, with "breadboard" ARDF equipment, and was deployed to VN twice before the "production" PHYLLIS ANN project was cranked up. The bird (S/N 45-0925) was eventually sent back stateside for upgrade, but not until the Phyllis Ann birds started to arrive. It did in fact essentially "wear out", DRILL PRESS, as noted, was a 2-ship collection-only project. The aircraft came from Korea, where they had first been modified for the role, ca. 1953-54, under project ROSE BOWL/BLUE SKY. The project actually pre-dated the 6994th by some weeks but once the 94th was established, the operators were assigned to the squadron. The aircraft were assigned to the 360th, although that later changed as well.

<sup>14</sup> USAFSS History of the 6994<sup>th</sup> Security Squadron 1 July – 31 December 1966 RCS: AU-D5 (AFS-1) dated 1 July 1967



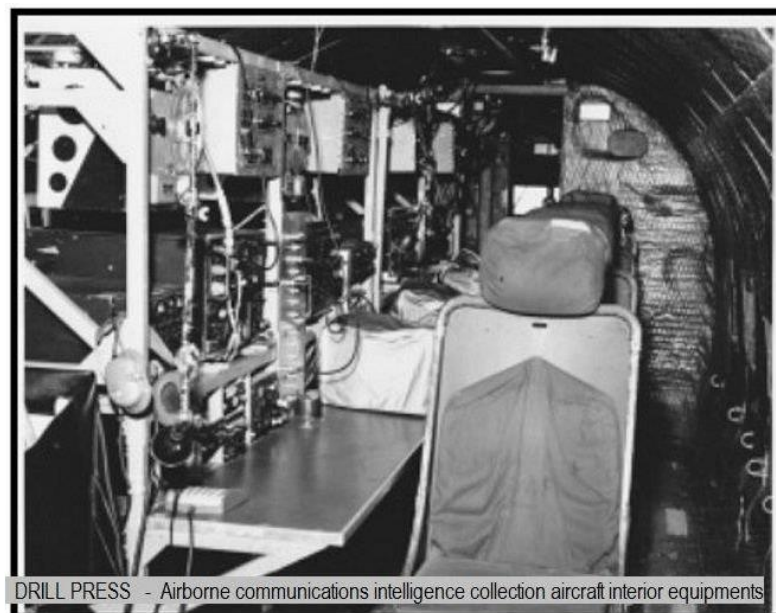
The following extract shows the equipment contained in the aircraft:

Drill Press Aircraft/Position Configuration (43-49680 Only)			
JUNE		JULY	
POSITION		SEPTEMBER	
1	2 - G133B HF Receivers 2 - AIC10 Intercomm	2 - G133B HF Receivers 2 - AIC10 Intercomm	2 - G133B HF Receivers 2 - AIC10 Intercomm
2	1 - G133B HF Receiver 1 - G120C Tape Transport 1 - G119H Record Amplifier 1 - AIC10 Intercomm 1 - Record Control	2 - G133B HF Receivers 1 - AIC10 Intercomm	1 - G133B HF Receiver 1 - AIC10 Intercomm 1 - G119H Record Amplifier 1 - G120C Tape Transport 1 - Record Control *1 - Patch Panel
3	1 - G133B HF Receiver 1 - G120C Tape Transport 1 - G119H Record Amplifier 1 - AIC10 Intercomm 1 - Record Control 1 - Antenna Transfer	2 - G133B HF Receivers 1 - AIC10 Intercomm 1 - Antenna Transfer	2 - G133B HF Receivers 1 - AIC10 Intercomm 1 - Antenna Transfer
4	1 - G175A VHF Receiver 1 - G120C Tape Transport 1 - G119H Record Amplifier 1 - G276A Demodulator 1 - SKL 212 Television Amplifier 1 - AIC10 Intercomm 1 - Record Control 2 - Antenna Transfers	1 - G175A VHF Receiver 1 - G120C Tape Transport 1 - G119H Record Amplifier 1 - G276A Demodulator 1 - SKL 212 Television Amplifier 1 - AIC10 Intercomm 1 - Record Control 2 - Antenna Transfers *1 - Patch Panel	1 - G175A VHF Receiver 1 - G120C Tape Transport 1 - G119H Record Amplifier 1 - G276A Demodulator +2 - SKL 212 TV Amplifier 1 - AIC10 Intercomm 1 - Record Control 2 - Antenna Transfers

\* Patch panel provided record capability from all positions.

+ Two SKL 212's were connected in series to increase signal strength of R401 signals.

Figure 10: Drill Press Equipment<sup>15</sup>



DRILL PRESS - Airborne communications intelligence collection aircraft interior equipments

Figure 11: Drill Press interior<sup>16</sup>

<sup>15</sup> Ibid

<sup>16</sup> <http://ec47.com/photoGalleries/view/ec-47-electronic-equipment/page:5>

### Phyllis Ann:

Phyllis Ann aircraft were ARDF aircraft. Initially there were 10 AN/ARD-18<sup>17</sup> equipped aircraft. The following sketch shows the internal layout of the aircraft:

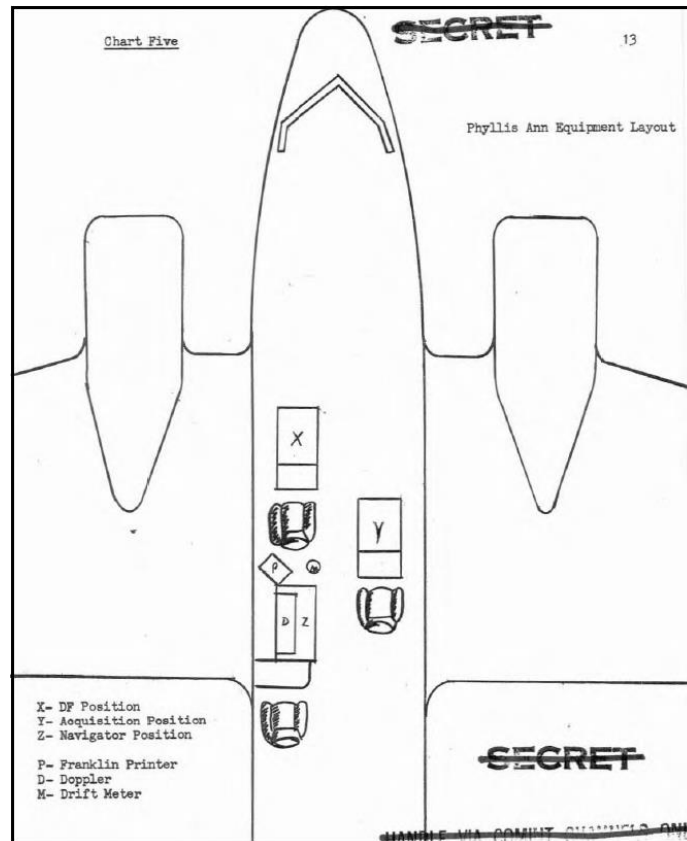


Figure 12: Phyllis Anne Equipment Layout<sup>18</sup>

In later years the codename of the aircraft were changed.

### USAF ARDF System

The ARDF system developed by the USAF<sup>19</sup> was different from the US Army. The system used, was based on side angle calibration, which made it possible to fix enemy transmitters in any direction without turning the aircraft. Without this feature, the crew would have to point the aircraft toward or away from the transmitter, as is the case with the aural null technique employed by the US Army aircraft. Therefore, side angle calibration reduced the possibility of compromise by the VC/NVA targets, and also enabled the crew to fix target radio transmitters that only remained active for short periods.

### Crew

<sup>17</sup> Airborne Radio Direction Finding (ARDF) System; manufactured by Sanders; became AN/ALR-34

<sup>18</sup> USAFSS History of the 6994<sup>th</sup> Security Squadron 1 July – 31 December 1966 RCS: AU-D5 (AFS-1) dated 1 July 1967

<sup>19</sup> The majority of the details of the USAF system are extracted from: <http://www.ec47.com/dir.htm> web page.

The crew of each aircraft consisted of two pilots (pilot and co-pilot), a navigator, a flight mechanic<sup>20</sup> and two ARDF operators.

*Note. In SVN, twelve aircraft had two additional search/acquisition positions, and five aircraft had two additional acquisition and jamming positions.*

### USAF ARDF Equipment

With the exception of an antenna on each wing and the nose, the EC-47 ARDF aircraft was to all external appearances, a standard C-47. The internal equipment made the aircraft system unique:

- **AN/ALR-34 ARDF:** An electronic ARDF unit (known as the "X" console) employed a "phase measurement" technique to determine the relative bearing of a signal to the aircraft (i.e. the angle formed by the direction of the radio signal and the aircraft heading). The AN/ALR-34 establishes the direction of the enemy signal, as a result of computing through a complex process, the time of arrival of the target signal at the three antennas on the aircraft wings and nose. The X console was manned by an operator<sup>21</sup>.
- **Y Console.** A target-acquisition position (the "Y" console) permits its operator to search various frequencies for an enemy signal. Later, additional operator (Z) and analyst positions were included.
- **KY-8 Radio:** Permits secure communications between the ARDF operators and DSUs.

Joe Martin expanded<sup>22</sup>:

#### ***EC-47 SIGINT Equipment***

*With the exception of ARDF antennas on each wing and the nose, the EC-47 was, to all external appearances, a standard C-47. The internal equipment made the aircraft system unique:*

***"X" (ARDF) Console*** (AN/ALR-34, and later ALR-35 and ALR-38.) *The USAF ARDF system employed a "phase **angle** measurement" technique to determine, by the time of arrival of the target signal at the three ARDF antennas on the aircraft wings and nose, the relative bearing of a signal to the aircraft (i.e., the angle formed by the direction of the radio signal and the aircraft heading).*

<sup>20</sup> Except in rare instances the mechanic was not essential for the mission.

<sup>21</sup> In an email to Bob Hartley on 20 Feb 2016, Joe Martin recalled: The Senior Radio Operator (in X/Y birds) determined who sat where, although generally he chose X, that being thought of as the position requiring the most skill/experience. With the exception of the linguist, who could go nowhere but Z1, same held true for the "Z birds" although on those missions the guy in charge was given the rather overblown title of Airborne Mission Supervisor (AMS). Neither SRO nor AMS was a function of rank, although all other things being equal, that was presumably the determining factor. Scheduling generally designated the guy with the most "in country" experience.

<sup>22</sup> Email to Bob Hartley 20 Feb 2016.

***“Y” Console.*** Originally intended as a target-acquisition position, the Y console mounted two HF receivers. In practice, the Y operator copied the traffic, notably call signs, of the enemy target being worked by X, maintained the target logs, and passed fix data to the DSU.

***“Z” Consoles.*** Approximately 30 aircraft were fitted with two collection-only positions. \* Z1 (forward) was manned by a linguist and fitted with HF and VHF receivers. Z2 (aft) was manned by a Morse operator searching for signals in the HF bands. Both Y and Z consoles were equipped with tape recorders, although Morse traffic was copied using MC-88 typewriters.

*\*Some 30 N and P model EC-47s were wired to accept the “Z” consoles, which could be switched in/out as desired. However, an equal number of Z consoles was not initially produced, meaning that not all Z-capable aircraft were actually so equipped. By late 1969 or thereabouts, it appears that this situation had been remedied. The EC-47Q models were fully equipped with X, Y, and Z positions.*

***“Q” Consoles.*** Five aircraft were equipped with the QRC-346 electronic warfare system (located in the Z positions) which, in addition to jamming signals, could “spoof” enemy communications. The Q system was never used for its intended purpose. However, since the standard X console ARDF gear was retained, these aircraft were employed in the same role as the Z-equipped aircraft, Q1 and Q2 being utilized in passive mode only.

***KY-8 Secure Voice System.*** Permitted secure voice communications between the EC-47 operators and DSUs via the FM-622A / ARC-54 FM transceiver. The KY-8 greatly expedited the passage of fix data, which otherwise required the use of time-consuming “one-time” encryption pads.

*There was no analyst position per se in the EC-47. When an analyst did fly, he typically utilized a long microphone cord enabling him to walk from position to position in the cabin. If not otherwise occupied, he could use the WWII navigator’s station (on the left side, just aft of the cockpit bulkhead) as a working area.*

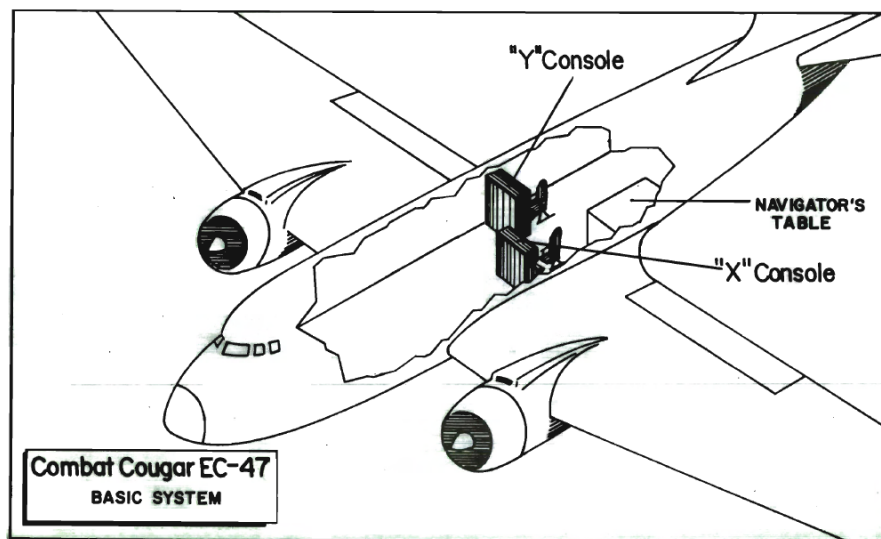


Figure 13: EC-47 Basic layout<sup>23</sup>

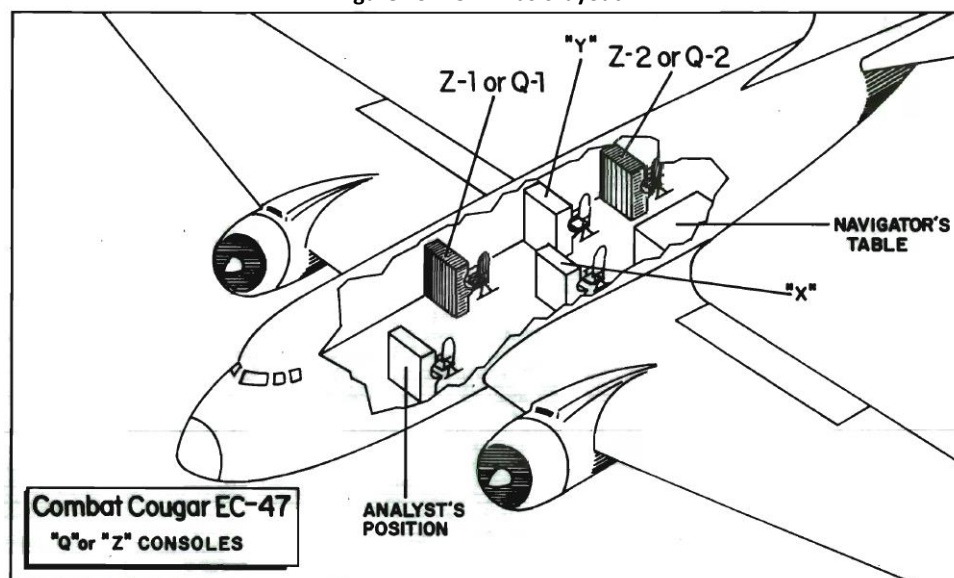


Figure 14: EC-47 Extended internal layout<sup>24</sup>

<sup>23</sup> [www.dtic.mil/dtic/tr/fulltext/u2/a486464.pdf](http://www.dtic.mil/dtic/tr/fulltext/u2/a486464.pdf)

<sup>24</sup> Ibid



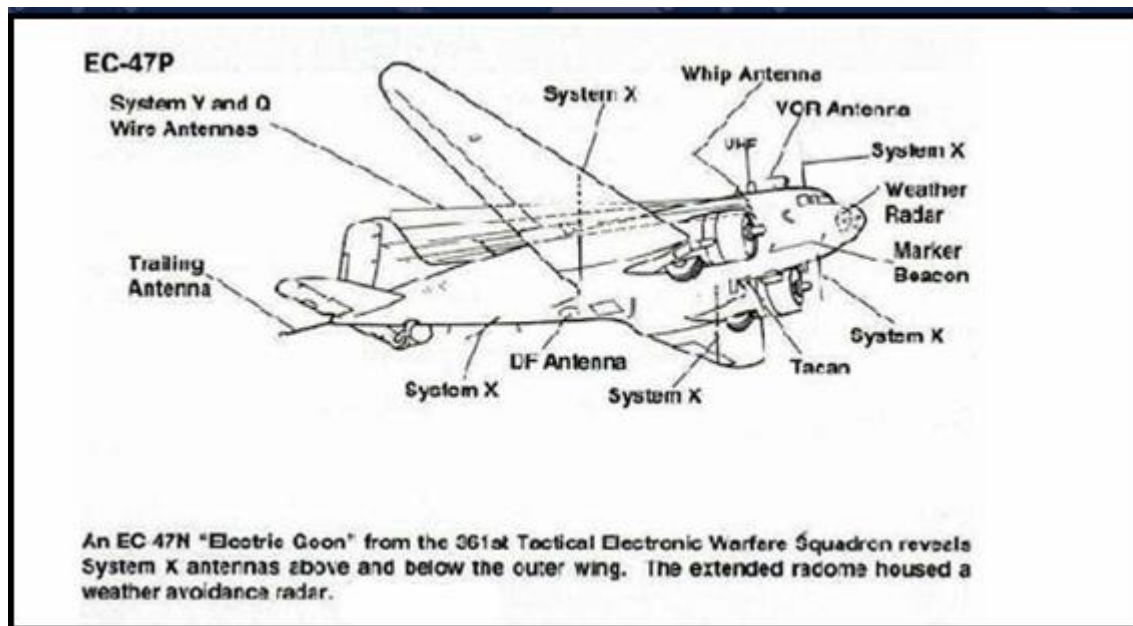


Figure 15: Schematic of EC-47 ARDF Equipment<sup>25</sup>



Figure 16: EC-47 Cockpit<sup>26</sup>

<sup>25</sup> Ibid

<sup>26</sup> <http://www.talkingproud.us/Military/Det3EC47s/Det3EC47s/Det3EC47sAircraft.html>



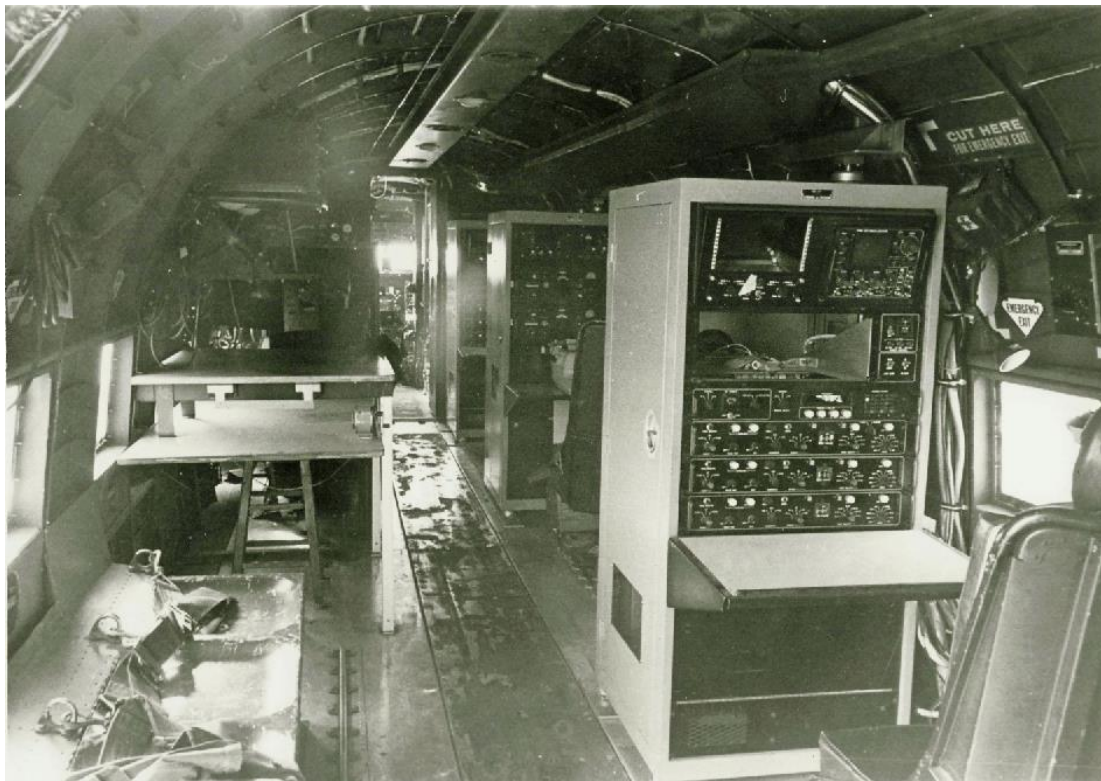


Figure 17: Interior of EC-47. From back 'X' and Navigator stations on left, 'Z1', 'Y' & 'Z2' on right<sup>27</sup>

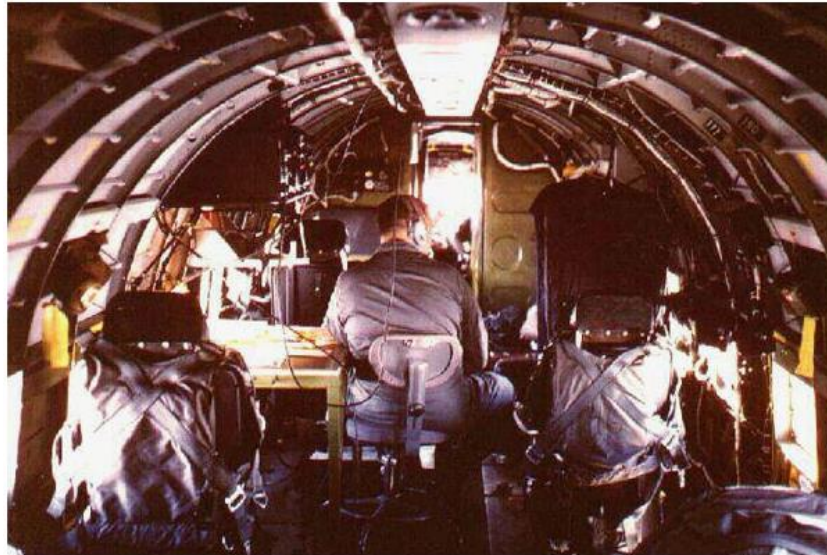


Figure 18: EC-47 with only 'X' and 'Y' ARDF<sup>28</sup>

<sup>27</sup> Photograph courtesy of Joe Martin, This aircraft was one of the 5 equipped with the QRC-346 EW "jamming" suite. The rearmost (Q2) position shows a couple of holes where modules are missing. Also, there is no MC-88 typewriter--standard equipment with which any US Ditty-bop of the Cold War era was quite familiar. The navigator's position is in the original side-mounted configuration, as are those in Figs. 18 & 19 which, BTW, must be of the earliest aircraft to arrive. Note the pencil sharpener and the stool stowed underneath the nav's plotting table. Note also the complete absence of the Y console in Fig. 19, and what appears to be simply a wooden table. Fig. 18 is not clear enough to make out exactly what the blob is where the Y console would be. At some point which I have yet to discover, all the nav positions were converted to the fore-aft configuration shown in Fig. 20 which shows the push buttons for a spanking new -35 or -38 system.

<sup>28</sup> Ibid



Figure 19: EC-47 interior - 'X' position on left<sup>29</sup>

### Navigational Equipment

To provide an accurate position of the aircraft for DF plotting, the navigator had access to the normal aircraft navigational aids plus additional equipment installed for the DF system:

- **Bendix Doppler Computer CPA-24 (AN/APN-179).** This computer enables the navigator to fix the aircraft's position within a tolerance of 0.6 percent of the distance travelled and 1-7 percent of cross track distance. At 120 knots, this means that the maximum allowable error is 1.8 nautical miles per hour.
- **C-12 Compass System.** The C-12 was one of the most advanced compass systems available. It gave an instant readout of aircraft heading within a tenth of a degree. It was accurate within 0.25 degrees

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<sup>29</sup> Ibid



Figure 20: Navigator's workstation<sup>30</sup>

The pilots had one non-standard piece of equipment, a Bendix Weather Radar, AN/APS-113, mounted on their instrument panels.

#### **Pre Mission Brief**

The pre Mission Brief was extensive and apart from the normal flight briefing for large aircraft, would include:

- Search area boundaries.
- Location of the using agency (DSU) and reporting requirements.
- Time of arrival and departure from the operational area.
- Location of known targets in the area.
- Target identities, schedules, frequencies and callsigns.

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<sup>30</sup> Ibid

## ARDF Operating Procedures

Normally the following procedure was followed to acquire a Fix.



Figure 21: ARDF workstation<sup>31</sup>

- The ARDF operator searches for and locates a signal.
- The signal is 'locked on' by the X operator. (At which time he turned the intercom knob to "Call", which overrode any other conversations, and announced "Nav [this is] X, lock on target *n*, signal strength [1 - 5].") As a practical matter, this was rarely less than 4 or 5.)
- A warning light appears on the navigator's console which signifies that a signal is active for prosecution.
- Simultaneously the ARDF needle on the navigators console will swing to point towards the target transmitter showing the position relative to the nose of the aircraft.
- When the pilot heard X's call she immediately rolled level and announced "level" over the intercom.
- When the aircraft is level and the DF needle steadied on the target the navigator will activate the system and printer.
- When the navigator depresses the enter button on his control panel, a Line of Position (LOP)<sup>32</sup> is taken by the system and printed out. This process would continue for at least three LOPs.
- When sufficient LOPs are taken the pilot and navigator would confer and depending on the time elapsed since the last Doppler set, the navigator might immediately give the pilot a heading towards the nearest "Dop Set" point. The longer the interval between sets, the greater the degradation of the aircraft location estimate.

<sup>31</sup> Ibid

<sup>32</sup> LOP is derived from the equipment computing the position of the aircraft, heading of the aircraft, speed, and angle of arrival of the transmitting signal to the aircraft.



- When the aircraft's position at the time the LOPs were taken is confirmed the navigator would plot the details from the printer and a fix on the target is determined.
- The Navigator would then pass to the Y operator: the fix position in UTM coordinates (including CEP), standoff range in nautical miles, the altitude of the aircraft, and the time of the last fix on the target. The operator then encrypts the information (if no secure voice available) and passes the information to the DSU.

The following graphic gives a representation how a basic fix is determined. It only shows two LOPs:

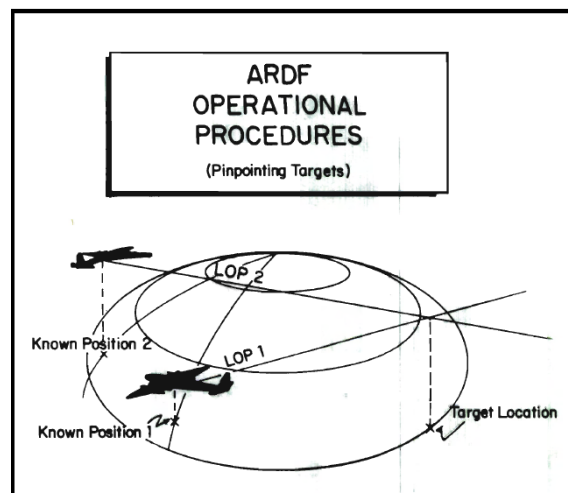


Figure 22: EC-47 Basic fix procedure<sup>33</sup>

Extract from Project Checo<sup>34</sup>.

*Once in the fraggd are, the procedure was for the intercept operators to search the frequency spectrum continually for significant transmissions. Once found by either a "Y", "Z" or "X" operator the "X" operator locked the ALR equipment on, and the ARDF equipment displayed a relative bearing to the target. As of the first LOP, no substantive range information was possible, although signal strength and needle movement could give an experienced navigator a fair approximation in many cases. Depending upon the information he had, the navigator positioned the aircraft in order to take subsequent LOPs. Two intersecting lines of position gave him a good idea of the enemy transmitter's range, as well as its position. Although six to ten LOPs were considered desirable, a navigator could accept a fix based on any three, if he considered them accurate.*

*An experienced "X" operator and navigator could and did take simultaneous fixes on more than one target, alternating frequencies as LOPs were taken and plotted. See Figure 7 for methods of plotting fixes and types of fixes determined.) [See figure 21] the most desirable method of fixing a target was to fly a single heading "innocent track" past the target, taking LOPs as they swung from nose to wingtip to tail. This was considered ideal for several reasons: one, the DF plane looked like any ordinary*

<sup>33</sup> [www.dtic.mil/dtic/tr/fulltext/u2/a486464.pdf](http://www.dtic.mil/dtic/tr/fulltext/u2/a486464.pdf)

<sup>34</sup> Project Checo Southeast Asia Report : The E-47 ins SEA April 1968 – July 1970 dated 12 Sep 70

airplane just flying by to a ground observer; two, the stand-off range was good; and three, Doppler errors were kept to a minimum. However, the navigator used whatever pattern would give him the necessary results. If a target was transmitting intermittently, a circular or elliptical pattern might be used to keep the aircraft in a favorable position for taking an instantaneous LOP, should the radio come up for a short burst.

The judgment of the navigator was of prime importance in evaluating the accuracy (circular error probable) of the fix.

Accuracy depended upon several factors, among them the known accuracy of the equipment, and the effects of weather and terrain upon given LOPs. Ideally, all LOPS should have intersected at a given point; in practice, however, the navigator usually had to do considerable editing, throwing out LOPS which, in his judgment, were faulty and retaining those which appeared accurate.

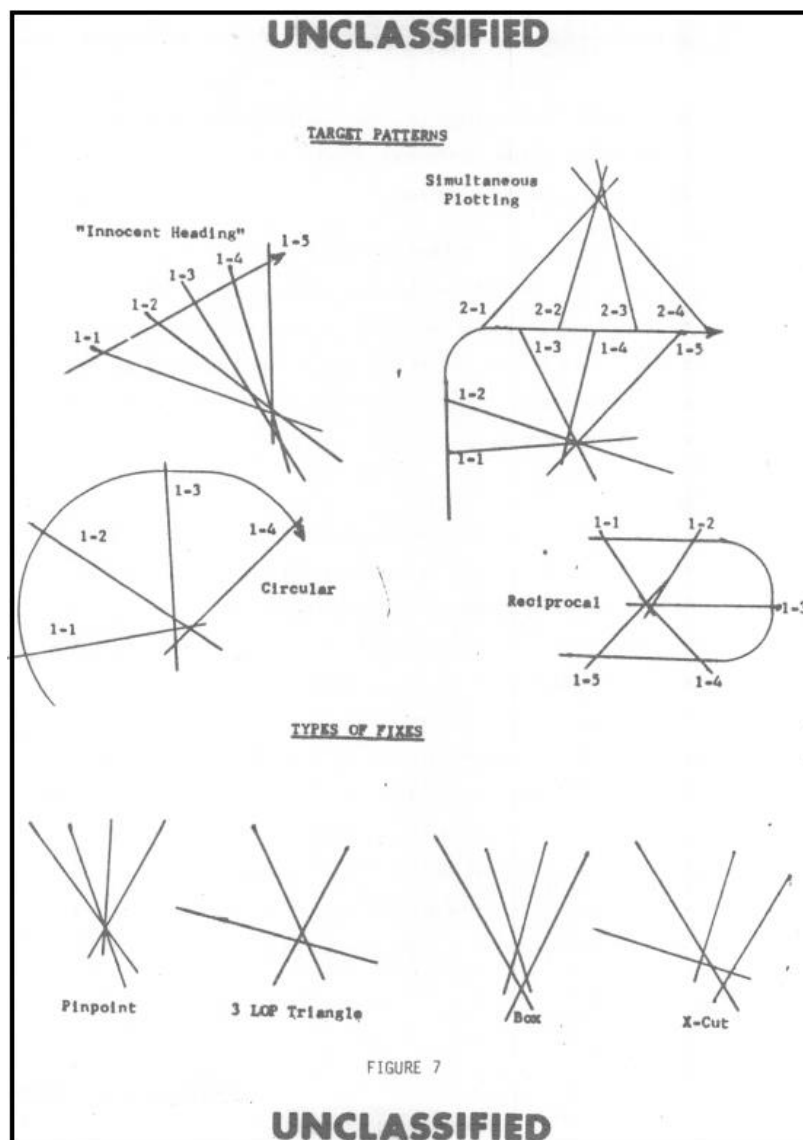


Figure 23: Types of Plots and Fixes



*The final step in the navigator's procedure was to assign a probable radius to the fix, ranging from 250 to thousands of meters. Influencing this determination were the time since the last Doppler update, the type of update (driftmeter<sup>35</sup>, MSQ-77<sup>36</sup>, TACAN<sup>37</sup> etc.), terrain effect, weather, and stand-off range.*

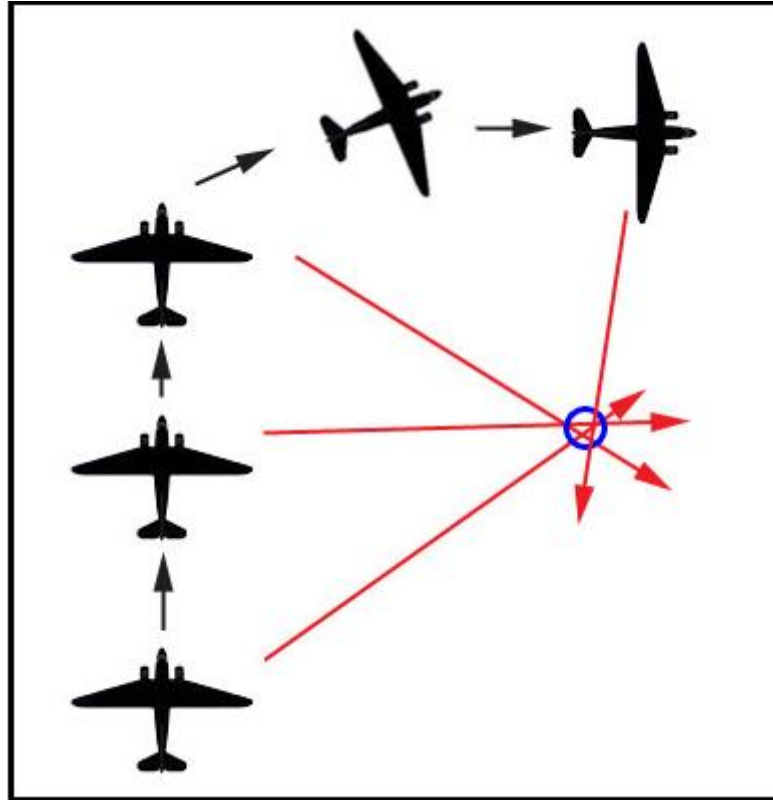


Figure 24: Exaggerated Graphic of a Fix<sup>38</sup>

In the main, the USAF provided many fixes, however, in the early days of operation at least 48% of their fixes had a CEP of 2000 meters or over.

<sup>35</sup> <http://www.talkingproud.us/Military/Det3EC47s/Det3EC47s/Det3EC47sAircraft.html> The drift meter was used by the navigator to locate the aircraft's position relevant to known spots on the ground. With this, the navigator could look directly under the aircraft to refine its position

<sup>36</sup> <http://fas.org/man/dod-101/sys/ac/equip/an-msq-77.htm> The AN/MSQ-77 radar system has a very distinguished history. At the time of the Vietnam War, the United States did not have precision navigation capabilities such as the Global Positioning Satellites (GPS). Aircrews, especially B-52 bomber crews, were not able to "see" many of the ground targets that they were attacking, and navigation systems were not precise enough to conduct the types of missions directed by the Johnson administration.

The United States Air Force developed the AN-MSQ-77 radar system to guide the aircraft to the target. This type of mission was called Ground Directed Bombing (GDB). The radar portion of the AN-MSQ-77 was capable of tracking aircraft anywhere within 200 miles of the radar system, so one radar system could cover the whole of North Vietnam and South Vietnam. To reflect this GDB role, the AN/MSQ-77 was originally called the "Radar Bomb Directing Central". It was designed with a vacuum tube type computer (1950's technology) and a "Plotting Board", which could draw a precision map of where a tracked aircraft was flying. These maps could precisely determine where an aircraft was in relation to a chosen target. The computer continuously calculated the altitude, airspeed, wind drift correction, and ground elevation changes, using the ballistics of the bombs that were being carried by the aircraft. The plotting board / computer operators would tell the aircrew to make minor corrections in their flight path, and then the exact moment when to drop their bombs, to ensure that the bombs would be on target.

<sup>37</sup> [https://en.wikipedia.org/wiki/Tactical\\_air\\_navigation\\_system](https://en.wikipedia.org/wiki/Tactical_air_navigation_system) A tactical air navigation system, commonly referred to by the acronym TACAN, is a navigation system used by military aircraft. It provides the user with bearing and distance (slant-range) to a ground or ship-borne station. It is a more accurate version of the VOR/DME system that provides bearing and range information for civil aviation.

<sup>38</sup> <http://www.talkingproud.us/Military/Det3EC47s/Det3EC47s/Det3EC47sAircraft.html>

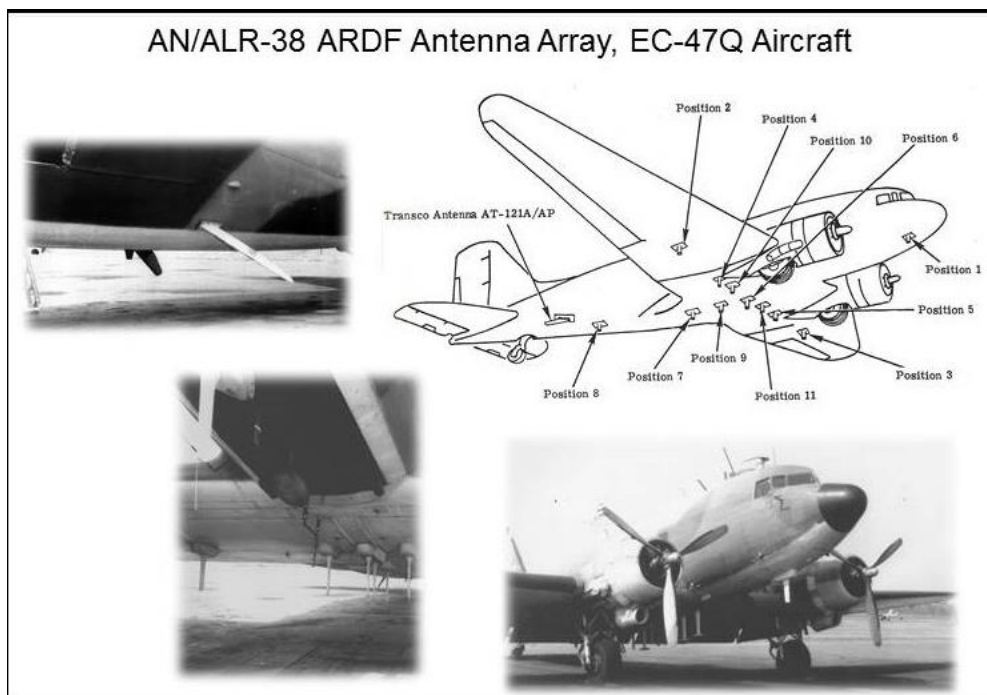


Figure 25: EC-47Q Aircraft Antenna Array<sup>39</sup>

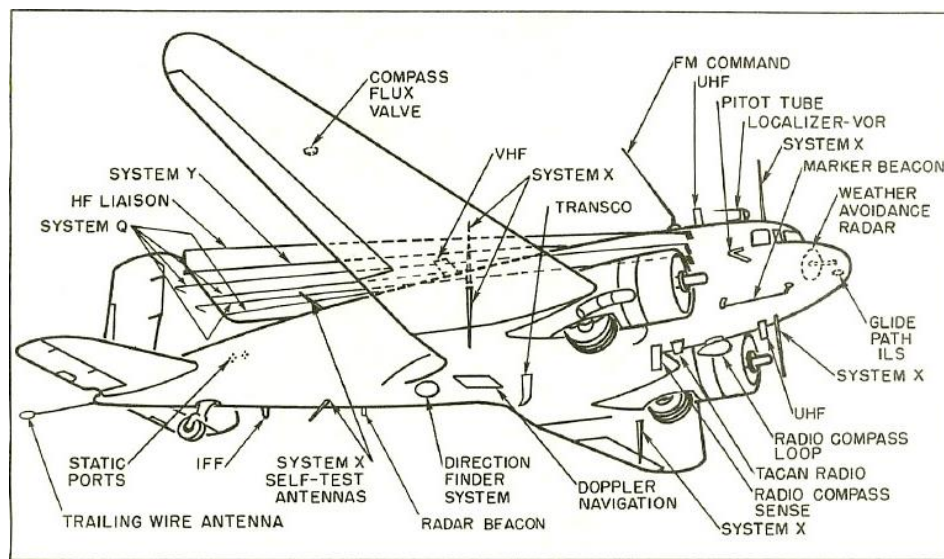


Figure 26: Aircraft Antenna Array

<sup>39</sup> Photos courtesy of Joe Martin. Attached are a couple of graphics showing the antenna arrays on the EC-47N & P models (AN/ALR-34 or -35 systems) and the Q models with the ALR-38 system. (Do not confuse the EC-47Q with the QRC-346 jammer birds, although the term "Q bird" was at times used for either.)

## A Navigator's Story

The following is an extract from:<sup>40</sup>



*The EC—47 was loaded with electronic equipment to detect and locate enemy communications. The navigation equipment was built around the Doppler Radar and a very high-speed printer that recorded almost simultaneously, the aircraft heading from a very accurate, gyro-stabilized compass, the read—out of the Doppler computer, and the bearing to the signal being located. This bearing was called a line of position (LOP) to the target signal. The signal intelligence equipment operated by the specialists consisted of stacks of radio receivers to detect the signals. The navigator was continuously in contact with the specialists using a private intercom. The pilots and engineer did not have access to this intercom since they were not cleared for this portion of the mission. There was a door between the pilot's compartment and the rest of the aircraft, and they were not allowed near us when we were working signals. There was also a normal intercom system for the pilots and navigator to communicate with each other.*

*The navigator had to monitor and use four different communication channels at the same time: To the ground Tactical Control Command, which controlled all air operations in our theater: the Army Artillery firing bases, to avoid being hit by one of our own artillery shells when they were firing: the "Guard" channel, which everybody in the air monitored and was used for emergencies or to warn of some hazardous condition; and to the signal of interest the specialists were working. The panel also included the two intercom channels. In the beginning it was very confusing, but in a short period of time I was able to sort it out, and it all started to make sense.*

*The North Vietnamese had employed a very sophisticated radio communication system between their headquarters and all elements of their Army and the Vietcong, throughout South Vietnam. They used "high frequency" (which is really very low frequency) radio signals that can, with very little power, transmit over long distances. They transmitted by dots and dashes signals which contained their messages. The radio signals we were attempting to find and locate very low power—only four watts. Their standard radio transmitter was very small. They were human powered by a generator with bicycle pedals pumped by a person lying on his back. The antenna was a wire about 100-feet long that was strung between two trees. These were very mobile and were continually moved.*

*The EC—47 was configured to pick up these weak signals. There were long metal whip antennas installed vertically near both wing tips and on the fuselage. A weather*

<sup>40</sup> [http://ec47.com/storage/UserFileFolder/Cameron\\_%5BAF\\_Museum%5D.pdf](http://ec47.com/storage/UserFileFolder/Cameron_%5BAF_Museum%5D.pdf)

*radar antenna was installed in the nose. This was the most identifiable characteristic of the aircraft—a black nose. They installed bigger engines and larger generators to supply the electricity for all the electronic equipment. The aircraft was required to be able to lose one of the two engines on takeoff and still climb to a safe altitude and land. This limited the fuel supply available to us to reduce the weight at takeoff. As a result all missions were limited to a maximum of seven hours. We had to fly at relatively low altitudes to pick up our signals and at relatively low speeds to conserve our fuel, but still maintain a speed of at least 100 knots to maintain the accuracy of the Doppler System. This put us within the capabilities of small-arms fire from the ground, and we occasionally picked up some holes. Their 37mm anti-aircraft could be devastating.*

*.....These areas were broken into patrol areas for reconnaissance. A crew would be assigned an area to patrol and a time to stay on station. The navigator would select several points on the ground that covered the patrol area upon which to dop-set on. When the aircraft arrived on station, we would troll for signals for almost seven hours.*

*When a signal was detected by a specialist, the navigator would direct the pilot to maneuver the aircraft to locate the source of the signal on the ground. The navigator would plot the LOPs from the computer readout and provide the geographic coordinates of the intersection of these LOPs. It took at least three Lops 60 degrees apart to pinpoint the location of the emitter. These locations had to be accurate within meters to be useful for the specialists. The specialist would combine the location with the signal properties and the contents of the translated message and report it directly by secure radio to the appropriate intelligence agency. Sometimes all the way back to the National Security Service Agency at Fort Meade, Maryland.*

#### **Accomplishments:<sup>41</sup>**

During its eight years of operations in Southeast Asia, the 6994<sup>th</sup> made major contributions to building the intelligence picture of the battlefield in Vietnam. Countless commanders relied on Signals Intelligence (SIGINT) and Airborne Radio Direction Finding reports when developing their battle plans. It has been alleged that 95 percent of the B-52 strikes conducted in Vietnam were based partially or in full on information provided by the 6994<sup>th</sup>.

One report of the effectiveness of the EC-47 came during a conversation between Gen. William W. Momyer, Commander, 7AF, and Col. Robert G. Williams, Commander 460<sup>th</sup> TRW, in May 1967.

Colonel Williams quoted General Momyer:

*I want all personnel in this mission to know that the primary and basic source of intelligence in this country comes from COMPASS DART (now COMBAT COUGAR) and I want the people in these squadrons to know it.*

The 6994<sup>th</sup> Security Squadron was recognized for its cryptologic excellence in 1969, when it won the Travis Trophy from the National Security Agency (NSA). The Travis

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<sup>41</sup> Extract from: <http://www.6994th.com/mission.html>

Trophy is presented annually to the Service Cryptologic unit judged to have made the most outstanding contribution to NSA's mission during the previous calendar year. In a message to the Commander, USAF Security Service, the Director of NSA stated:

*Information has been brought to my attention relative to an exceptional SIGINT contribution which was made by personnel of the 330<sup>th</sup> RR Co, and the 6994<sup>th</sup> Security Squadron in South Vietnam. It is noted that through the combined efforts of personnel in these units, timely and very vital intelligence information was made available to tactical commanders which contributed directly to the engagement with elements of the PAVN 325C Division on 10 May 1968. Further and more important, U.S. forces incurred very light casualties because of their knowledge of the situation as derived from SIGINT.*

It was noted that this engagement took place within 800 meters of an ARDF fix made on 6 May 1968.

The NSA director continued:

*The efforts of all those involved in the production of SIGINT information which results directly in the saving of U.S. lives is deserving of the highest praise and I take this opportunity to extend my sincere gratitude and recognition for a job well done to those men involved.*

Joe Martin related<sup>42</sup>:

*On 30 April 1970, President Richard M. Nixon announced that US and ARVN forces would enter Cambodia to attack and destroy the VC/NVA base areas there. Heretofore, our EC-47 missions out of Tan Son Nhut often flew "with the shadow of the aircraft in Cambodia" but carefully avoided actually "crossing the fence."*

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<sup>42</sup> Email to Bob Hartley 21 Feb 2016.





Figure 27: Backend crew of a 2 May 70 Mission<sup>43</sup>

*On 2 May, the first two EC-47s fragged for cross-border operations took off from TSN more or less simultaneously. The photo shows one of those backend crews. (Standing, L to R: Joe Martin, Allen Johnson, Dan Whitney. Kneeling, Rich Renkas, Dwight Hartung). The picture would've been taken just after pre-flight. Survival gear and parachute harnesses have already been stowed inside, but we're still wearing the Smith & Wesson .38 pistols. As I recall, we were ordered to load them (a first and only in my experience) and a loaded weapon was to be kept in one's immediate control for the duration of the mission which, aside from the cornucopia of ARDF targets, turned out to be completely routine. My Form 5 shows we logged 5.4 hours.*

*After 45 years, it struck me that there appears to be one man too many in this photo. It would stand to reason that the "extra" was an analyst, although my recollection is that all but Rich "Spirus T" Renkas (linguist) were Morse ops. After all this time, I simply don't know. In any case, although I had by this time flown 29 missions, I was still the new guy in this group, and thus relegated to Z2.\**

*\* Allen would've been the AMS.*

*The various types of apparel is worthy of note. Martin is in the green "Nomex" fire-resistant flight suit issued to all SEA aircrew ca. early 1970. "Old hands" Johnson and Hartung wear the traditional gray cotton suits, while Renkas and Whitney have opted to go with their "jungle fatigues." Sometime in late 70 or early 71, presumably once sufficient supplies had accumulated, word came down that henceforth only Nomex suits would be worn.*

<sup>43</sup> Photograph courtesy of Joe Martin



## Casualties

### EC-47 Airframe and Aircrew Losses (in-flight)



Hostile Fire (All incidents)				Operational Accidents (KIA only)			
09 March 1967	"Tide 86"	361st TEWS	7 KIA	08 October 1969	"Prong 33"	361st TEWS	6 KIA
11 March 1968	"Brew 41"	361s TEWS	No KIA	21 November 1972	"Baron 56"	361st TEWS	2 KIA
05 February 1969	"Cap 72"	362nd TEWS	10 KIA				
22 April 1970	"Cap 53"	362nd TEWS	2 KIA				
05 February 1973	"Baron 52"	361st TEWS	8 KIA				

Figure 28: EC-47 Airframe and Aircrew Losses<sup>44</sup>

## Awards

6994th Security Squadron (SS)	
<b>Presidential Unit Citation (PUC)</b>	
<b>Air Force Outstanding Unit Award (AFOUA)</b>	
<b>AFOUA with Valor, 15 April 66 - 31 May 67, DAFSO GB-81</b>	
<b>PUC, 1 September 67 - 10 July 68, DAFSO GB-124</b>	
<b>PUC, 11 July 68 - 31 July 69, DAFSO GB-804</b>	
<b>AFOUA with Valor, 1 July 69 - 30 June 70, DAFSO GB-850</b>	
<b>AFOUA with Valor, 1 July 70 - 30 June 71, DAFSO GB-43</b>	
<b>AFOUA with Valor, 1 July 71 - 30 June 72, DAFSO GB-39</b>	
<b>AFOUA with Valor, 1 July 72 - 30 June 73, DAFSO GB-819</b>	
<b>Republic of Vietnam Galantry Cross with Palm,</b>	
<b>15 April 1966 to 28 January 1973 DAF SO GB352 1975</b>	

Figure 29: List of awards<sup>45</sup>

<sup>44</sup> Email from Joe Martin 2 March 16.

<sup>45</sup> <http://www.ec47.com/sqdaward.htm#6994>