FRONTISPIECE RA3B Skywarrior

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The aircraft has 12 cameras, 16 camera ports, 5 hours endurance with aerial refueling and carrier-landing capability.

(*Abstract on next page*)

DURING WORLD WAR I the primary mission of Naval Aviation was observation. Aerial photography in today's Navy has evolved from this early start, making rapid strides in World War II and the ensuing period. Aerial camera systems have been adapted to such aircraft as the B24, the P-2 *Neptune*, and the AJ *Savage*. Since its inception, the Navy has maintained a cartographic capability to provide cartographic support for Navy and Marine Corps operations. In addition, many projects have been accomplished for the Naval Oceanographic Office, the U. S. Army Topographic Command, and the cartographic agencies of other countries, including Australia, the Republic of Korea, and Thailand.

The U. S. Navy's cartographic capability is maintained at present by Heavy Photographic Squadron SIXTY-ONE (VAP-61), a unit under the operational control of the Commander of the U. S. Navy's Seventh Fleet. VAP-61 is based at the U. S. Naval Air Station, Agana, Guam, Marianas Island, and is capable of deploying detachments of RA-3B *Skywarriors* aircraft, personnel, and support equipment aboard aircraft carriers or to remote land bases. The period since 1956 has seen VAP-61 involved in cartographic operations in New Guinea (staging from Australia), the Philippines, Okinawa, Korea, Hawaii, many of the small Pacific Islands, the Republic of Vietnam, Thailand, and other areas. The last three of these are illustrative of cartographic operations in general, some specific problems, and the technology used to solve them. They will be discussed in detail.

NAVY CARTOGRAPHIC efforts have contributed substantially to our efforts in the Vietnam conflict. When the tempo of operations increased in 1956, the available maps of the country were insufficient. Between November 1965 and April 1966, Heavy Photographic Squadron SIXTY-ONE completed the photography necessary to produce 1:25,000 scale picto maps of South Vietnam. This project, accomplished for the Army Map Service,

encompassed an area of 65,000 square miles, and required 29,500 flight-line miles. In 1967, 2415 flight-line miles of color photography was completed of the South Vietnamese coast. This photography was used for charting and water depth determination studies by the Naval Oceanographic office. In connection with the Vietnam operations, two separate cartographic projects were accomplished in Laos at scales of 1:50,000 and 1:25,000 involving over 45,000 flight line miles.

In these projects the photographic aircraft refueled in flight from a KA3B tanker in order to make maximum utilization of the time during which the sun angle was greater than 30 degrees. Photography was obtained of North Vietnam up to 20 degrees north latitude. This photography was also used to produce pictomaps (Fig. 1) which were of great value to strike aircraft and search and rescue operations in North Vietnam. In 1968 cartographic coverage of the Demilitarized Zone was requested by the U. S. Army Topographic Command in order to map the area. This project was completed by VAP-61 in one month. The Navy cartographic effort in Southeast Asia was extensive, and its value to military operations there was proven beyond any doubt. (Fig. 1 is on page 151.)

ABSTRACT: *The U. S. Navy in the post World War II period has possessed a cartographic capability, enabling it to provide the necessary mapping and reconnaissance to support Navy and Marine Corps operations. Aerial camera systems have been adapted to such aircraft as the B-24, the P-2 "Neptune," and the AJ "Savage." One of the present-day examples of this adaptation is the U. S. Navy's RA-3B Skywarrior, developed from the A3B strategic bomber. With 12 cameras, 16 camera ports, over 3 hours endurance, aerial refueling, and carrier-landing capabilities, the Skywarrior is versatile, to say the least. A crew of three and dual photographic viewfinders facilitate smooth, well-coordinated operations. Focal lengths from 1.75 inches to 36 inches are available, as well as radar photography and remote sensors. The cameras are fired by a computer-controlled electronic pulse. The accessibility of the cameras in flight greatly increases the reliability of the system.*

THIS YEAR* has seen the completion of 63,000 flight-line miles of cartography in Thailand, a project for the U. S. Army Topographic Command, in cooperation with the Royal Thai Survey Department. Consisting of complete coverage of the country at a scale of 1:50,000, this project is particularly significant because of the problems which were overcome during its execution. Staging from Don Muang Air Base, at Bangkok, VAP-61 covered the entire country, from the Malaysian border (400 miles south of Bangkok) to the Laotian border (350 miles to the north and northeast), on occasion utilizing air refueling to increase on-station time.

The greatest single hinderance encountered was weather; both clouds and haze. The rapidity with which clouds normally formed during the day and the lack of accurate weather observations contributed substantially to this problem. This was especially critical in the lower Kra Isthmus (the area just north of the Malaysian border). (Satellite weather depictions were used to some extent, but these were often not recent enough to be of value). Frequently the haze would be within tolerance for photography, but forward visibility would be such that the crews could only see vertically and had great difficulty accomplishing flight line navigation. This required very precise navigation just to locate the flight line in the beginning. On occasion the combination of sun angle and haze would necessitate that a flight line be flown only away from the sun.

Second only to weather, was the difficulty of locating reliable check points in certain areas of Thailand—particularly the Northwest and the lower Kra Isthmus. The available charts of these areas were depicted as uncharted, or were out of date to the extent that many prominent cultural features were of no value to the crews. This often left only terrain features, which were extremely difficult to discern, due either to the ruggedness and similarity of adjacent areas, or to poor depiction on the flight charts. In these circumstances a base and cross line method was applied.

TO FACILITATE early evaluation of the film

* 1971.

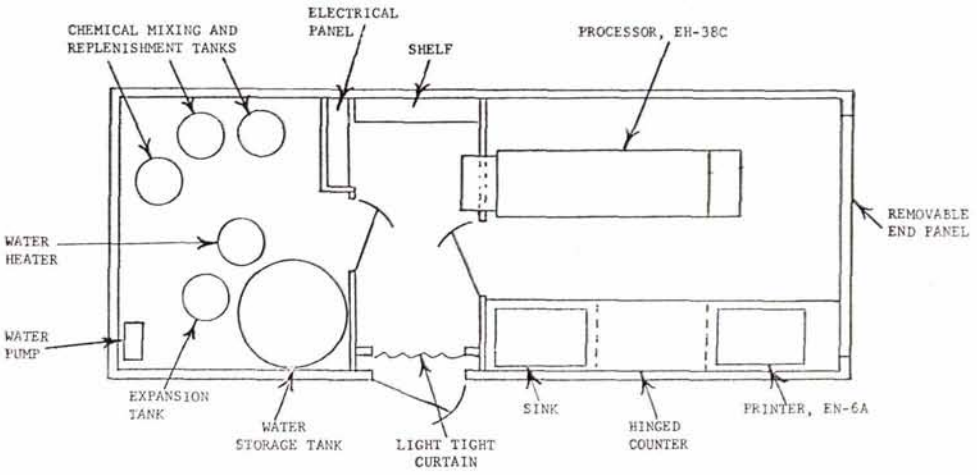

FIG. 2. ES-40 processing trailer

and to avoid duplication of efforts, a mobile processing laboratory was located at Don Muang adjacent to the Royal Thai Survey Department's hangar and ramp area, which was used by the VAP-61 detachment. This was composed of two ES-40 processing trailers (see Figure 2) and one administrative trailer combined to form a single unit (Figure 3) with its own electricity and all components necessary for processing aerial film, making prints as necessary, and effecting *quality control* of the operation. This arrangement was ideal, allowing the flight charts to be updated daily. It also allowed the flight crews to learn the maximum from their experience, by viewing their film within minutes after the mission. Where an area was photographed incorrectly in a particularly difficult area, some prints were made, if feasible, with the correct flight line drawn on them for the use of the crews on the follow-up mission. These trailers can be used individually if desired. They can be transported in a C-130 *Hercules* aircraft and even dropped by parachute, four aircraft being required to move a complete laboratory.

In addition to the large mapping project in Thailand, VAP-61 was instrumental in obtaining cartographic coverage for the Pa Mong Dam project. This project consisted of 3094 flight line miles along the Mekong River on the Thailand-Laos border, and was completed in February 1969.

The "Trust Territory of the Pacific Islands Project," underway at the time of writing consists of over 5400 flight line miles of black-and-white, color, and infrared photography.

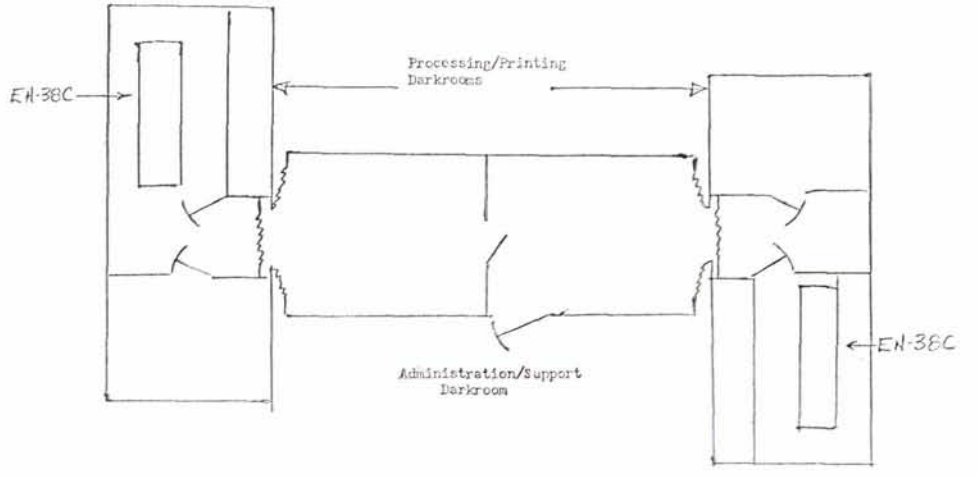

FIG. 3. Complete photographic laboratory

The islands involved are Truk, Palau, Ponape, Ulithi, and the West Caroline Islands.

THE AERIAL photography, flown by VAP-61 at altitudes between 3,000 feet and 30,000 feet, will be used to produce nautical charts and publications, and to update information in the Department of Defense Bathymetric and Chart Libraries under the cognizance of the Naval Oceanographic Office. Specifications for the project include a sun angle of 22 to 36 degrees, and low tide for the color film in order to gain the maximum information about water depths, bottom contours, channels, and harbor approaches. As always, weather is a critical factor. Small cumulus clouds, which form due to diurnal heating of the islands, are difficult to predict and the rapidity of changes in the weather aggravates the problem. Other difficulties are the large distances which must be traversed to get to the target areas and the minimal radio navigational aids available. However, the range of the RA3B and its celestial and radar navigation capabilities have successfully overcome these obstacles.

The RA3B, like most other photographic aircraft, resulted from the adaptation of a camera system to an existing aircraft—the A-3 *Skywarrior*, originally designed as a strategic bomber. The RA3B (Frontispiece), since its introduction in 1959, has been the U. S. Navy's primary cartographic aircraft. The twin-jet aircraft, built by McDonnell-Douglas, is capable of operating at altitudes in excess of 40,000 feet. It has a crew of three consisting of a pilot, a photographic navigator, and a photographic technician. The *Skywarrior*'s range (over 2000 miles) and its endurance (in excess of five hours) enable it to perform a wide range of missions. A carrier-based RA3B utilizing in-flight refueling can fly a photographic mission virtually anywhere on the globe.

ONE OF THE notable features of the RA3B is the viewfinder system. Both the pilot and the navigator have Librascope Viewfinders giving them four different views of the area being photographed. One of the views, called the *wide-angle vertical* (Figure 4), has a *travelling grid* which is linked to the cameras through a computer. The movement of the travelling grid is synchronized with that of a point on the ground. The computer, having been programmed for the camera position, format, focal length, and depression angle, interprets

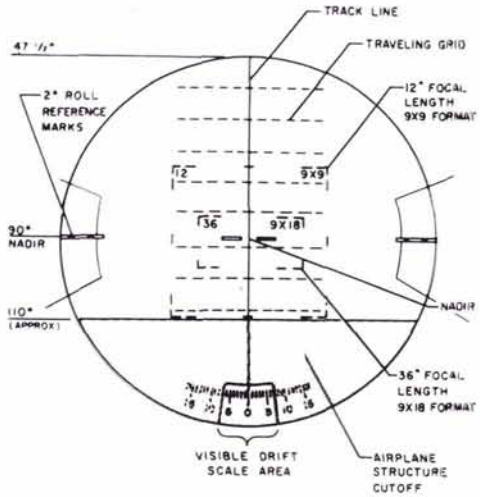

FIG. 4. Wide-angle vertical view

the movement of the travelling grid in order to fire the cameras at the correct interval. The travelling grid is designed to provide 60 percent overlap (normally required for reconnaissance). However, with proper interpolation, it can be used to get the 56 percent overlap normally specified for cartography.

Another use for the *wide angle vertical* view is its ability to see $42\frac{1}{2}$ degrees forward and 20 degrees aft of the aircraft. This enables the crew to get a longer look at a terrain feature, and sometimes makes it possible to positively identify a checkpoint that would otherwise remain obscure due to its being difficult to recognize from a forward view alone. In some applications where haze is a big factor, the forward views are virtually useless; yet the vertical views will enable the crew to complete the mission. Another view, the *narrow-angle vertical* (Figure 5), makes possible drift determination with its grid of parallel lines. The grid can be rotated 15 degrees left or right by either the pilot or the navigator. If it is rotated, all four views in both viewfinders rotate also. In addition, several of the camera mounts possessing *remote azimuth* track with the viewfinders, thus automatically orienting the cameras along the line of flight.

THE VIEW WHICH is most often used is the *wide-angle forward* (Figure 6). This view gives the crew a wide field of vision ahead of the aircraft. It includes a track line, a drift scale, a nadir point, and format and sixty percent overlap marks for both 6-inch and 12-inch cameras. In the event of a travelling-grid malfunction, it is possible, even in terrain of

FIG. 1: VINH, NVN, PICTOMAP EXTRACT

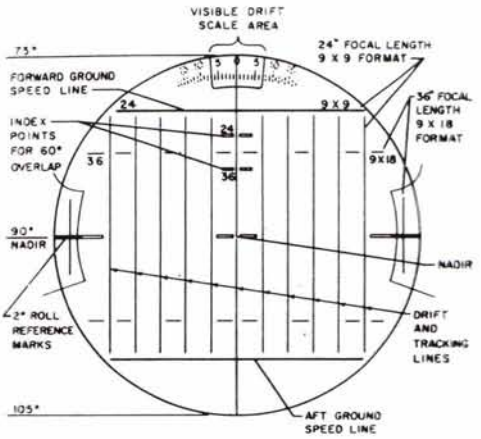

FIG. 5. Narrow-angle vertical view

varying elevation, to use the overlap marks so as to fire the cameras manually at the correct interval.

The remaining viewfinder view is the *narrow-angle forward*. This view contains only a track line, but enables the crew to see as far ahead of the aircraft as the horizon. It is particularly useful in aligning the aircraft with a distinctive terrain feature some distance away.

The dual viewfinder system facilitates maximum coordination between the pilot and navigator. It enables them to devote their efforts to different areas when practical. For example, in rugged terrain with varying elevations, the interval is changing constantly. It is frequently necessary for the navigator to monitor the travelling grid almost continuously while the pilot uses a different view to keep the aircraft on flight line. Likewise, the navigator can switch to the *narrow-angle vertical* view to determine drift without interfering with the pilot's presentation. The navigator has a control panel for each camera station enabling him to program the cameras and to determine how much film remains on each magazine.

The third crewman is stationed aft in the photo compartment during photographic operations. He turns the stabilization on and off and continuously monitors the cameras while they are operating. His presence in the aircraft significantly increases its versatility. Malfunctions of the cameras and stabiliza-

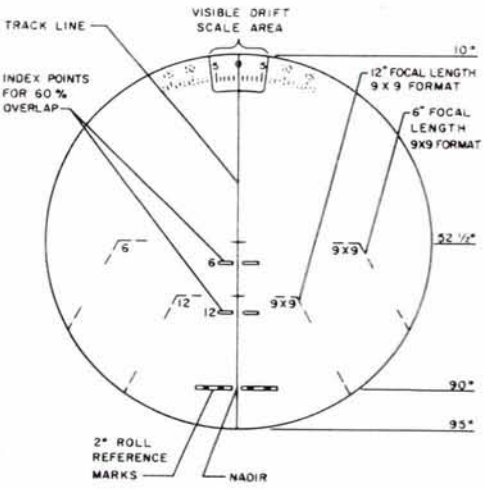

FIG. 6. Wide-angle forward view

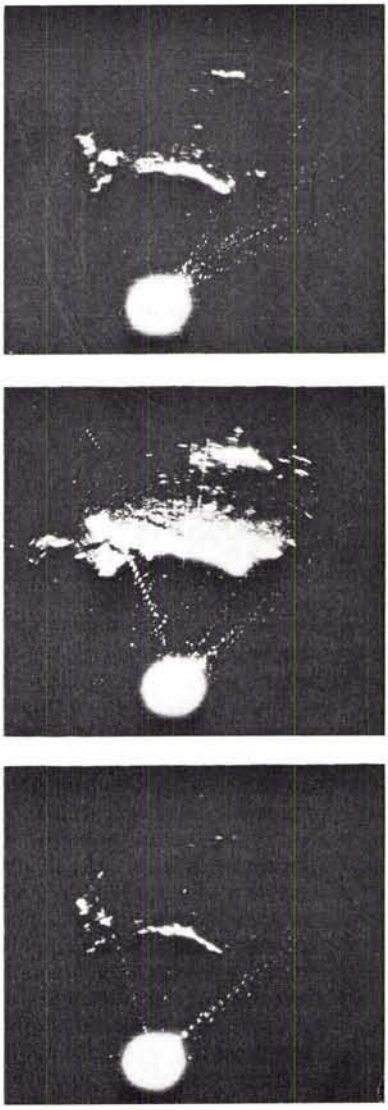

FIG. 7. Triple-gain radar photograph

tion system are frequently detected and corrected prior to their adversely affecting the mission. If a magazine fails or its film is expended, it can be changed. Electronic cables can be replaced. If the pitch stabilization malfunctions, pitch can be set in manually by the photographic technician.

In addition to having a cartographic capability, the RA3B is a very versatile reconnaissance aircraft. It has 16 camera ports and can carry 12 cameras, ranging in focal length from 1.75 inches to 36 inches and formats from 35 mm to 9 inches by 18 inches. The cameras can be mounted with a wide variety of depression angles, including a five-camera fan or a seven-camera fan to give horizon-to-horizon coverage. The aircraft computer can be programmed to give the desired overlap on individual cameras used simultaneously in many different reconnaissance applications. A 70-mm radar recorder camera mounted on the primary radar scope gives the RA3B a radar photography capability. As programmed, the radar camera automatically fires at an interval determined by the range of the presentation selected on the ASB-1 radar scope. This arrangement is particularly significant because of its triple-gain feature (Figure 7) which allows the camera to take three successive frames of the same presentation at three different levels of intensity. This facilitates more productive interpretation of the radar photography.

The U. S. Navy's cartographic aircraft have proven their value fulfilling difficult photographic requirements for aerial mapping, military reconnaissance, and various technical and scientific projects. The future will undoubtedly see new camera systems adapted to new aerial platforms to develop and maintain this important capability further.