Guided Missiles U.S. Navy The Pioneer

by R. Adm. D. S. Fahrney (USN Ret.)

Historians have overlooked the early developments that led to the remote control of airplanes and their counterparts, the guided missiles. That such an important area of technological evolution should have been bypassed is due to the fact that the prime originating and initiatory agency, the U.S. Navy's Bureau of Aeronautics, carried out the pristine developments in a highly confidential atmosphere just prior to, during, and for some years after, World War II. Further, the impact of the employment of the V-l Buzz Bomb and the V-2 Rocket by the Germans overshadowed developments in this country and yet they found no requirement for missile guidance systems to hit such a wide target area as London. A ballistic-type missile was all that was needed so the V-l and V-2 were gyro-stabilized and programmed to fly a preset course and distance with no further directive or guidance gear required. On the other hand, the U.S. Navy was interested in the creation of a missile that could hit a distant ship target unerringly by the use of a guidance system.

It is not generally known that the world's first guided missile was designed, fabricated and tested in the United States more than two years before such a development occurred in Germany contrary to what historians of the World War II period would lead us to believe. Further, there is not an awareness that the U.S. Navy's Bureau of Aeronautics (BuAer) developed the world's first guided missile in each of the four categories that define the use of this weapon. This is a fully documented fact as the following listing will show (in order of their successful introduction).

1. 14 September 1938—AIR TO SURFACE—N2C-2, Curtiss Training Plane Drone; dive tests on USS UTAH (target ship)—radio controlled, visual guidance.

2. 9 April 1942—SURFACE TO SURFACE TG-2 Torpedo Plane Drone; torpedo attack on a maneuvering destroyer; radio controlled; television guidance.

3. 13 June 1950—SURFACE TO AIR—*Lark* guided missile by Convair with Raytheon self-seeking radar guidance system; intercepted an F6F target drone.

4. 3 December 1952—AIR TO AIR—*Sparrow* guided missile by Douglas Aircraft Co. with Sperry radar beam rider; intercepted and destroyed an F6F target drone—launched from an F3D fighter plane.

Before a remotely controlled missile development could be realized certain preliminary studies had to be made of the successes gained in related fields of investigation, as the radio control of an airplane. Surface craft, both land and water, as well as underwater torpedos, had been remotely controlled by radio by John Hays Hammond, Jr., in 1917 and 1918. The first attempt to fly an airplane by radio control was carried out by the Navy's Bureau of Ordnance at the Naval Proving Ground at Dahlgren, Virginia. An N-9 seaplane training plane equipped with a Norden automatic pilot and a keyboard teletype controller (permitting a set value of turn, climb, or glide) was readied for a flight without a safety pilot on 15 September 1924. The N-9 was taken off smoothly by radio and maneuvered for 40 minutes. A hard landing was made that damaged the float and the plane sank. A Vought seaplane, VE-7H, was next equipped with automatic pilot and radio control gear and was flown without a safety pilot on 11 December 1925. During takeoff the plane porpoised four times, each more violent than the last, causing the pontoon struts to carry away and the plane sank in eight feet of water.

Now it is important that we review in some detail the pioneering effort of the Navy's Bureau of Aeronautics (BuAer) in the

Lt. Commander D.S. Fahrney at start of Radio Control of Aircraft Project in 1936.

Pictured in front of a Stearman-Hammond JH-1 target drone are the pioneers of radio-controlled aircraft and guided missiles. From the left are: Mr. W. Wait, AMMIC L.B. McKeon, AMMIC H.O. Schultz, ACCM L.E. Herzog, Chief Radioman L.W. Hendrickson, Lt. Cdr. D.S. Fahrney, Warrant Officer S.E. Herbst, ACCM F. Wallace, ACCM W. Bowlin, AMMCI H.E. Foster and G. Spangenberg.
(Author's Collection)

development of a successful radio-controlled airplane. This and other early work by BuAer played a significant role in the revolution of the weapons of war and in the initiation of the age of space exploration. Certainly the radio control and guidance equipment in use today, in missiles and spacecraft, owe their pedigree to those first faltering (but eminently successful steps) taken by a small band of pioneers at the Naval Aircraft Factory (NAF) at Philadelphia, Pennsylvania, and at the Naval Research Laboratory (NRL) at Anacostia, D.C. It is this writer's opinion that the developments in the radio control and guidance and stabilization systems are as important as the vehicle developments.

Our historical review will set forth the fact that the BuAer developed the first guided missile in the world in each of the four categories: Air to Air, Air to Surface, Surface to Air, and Surface to Surface.

The story begins with an unheralded and unpublished flight of a full-scale airplane under radio control and with no safety pilot at Cape May, N.J., on the 23rd of December 1937. This was called a "NOLO" flight being a contraction of "NO PILOT."

The orders setting up the radio control of aircraft project resulted from an urgent requirement to supply realistic aerial targets for the training of the antiaircraft gunners of the Fleet and to perfect the fire control equipment. Antiaircraft practices had become so stereotyped and artificial, in firings on sleeves towed by aircraft at set altitudes and speeds, that little realism could be gained thereby. The Chief of Naval Operations (CNO), Admiral W.H. Standley, while on an official trip to England early in 1936, witnessed firing tests on the radio-controlled aircraft target called the *QueenBee* and he was impressed with the operations and the results obtained. On his return to Washington, D.C, he conferred with the Chief of BuAer, R.Adm. E.J. King, who he found was in complete agreement with his view that it was necessary to develop a realistic target for antiaircraft firing practices. On the 23rd of March 1936, CNO sent a letter on the subject to the Bureaus of Ordnance, Aeronautics and Engineering calling their attention to the urgent need for radio-controlled aircraft targets for realistic training of shipboard gunners and he outlined the characteristics of the plane and the performance that was desired. He received prompt and enthusiastic replies from BuAer and BuEng but BuOrd regretted that the services of Carl L. Norden and his staff were not available as they were totally involved in the development of the Norden Bomb Sight and further, the crowded condition at the Dahlgren Proving Ground precluded work there on such a project as radio control of aircraft. The BuOrd letter also observed that "the cost of provision and operation of such targets for routine training of antiaircraft batteries would be out of all proportions to the benefits obtainable thereby." It will be interesting to see that the BuAer carried on the successful development with a small expenditure of funds.

On the 1st of May 1936, the CNO authorized the BuAer and BuEng to proceed with the development of radio-controlled aircraft targets and gave BuAer primary cognizance over the project, which was to be pursued at high priority. On the 20th of July 1936, the author was ordered to duty as the \officer-in-charge of the project and given three to five years to accomplish its objectives. The orders also stated that a study of all previous work in the field of radio control should be made and then a plan submitted for the execution of the project. On 6 August 1936, a plan was submitted which called for the development of equipment that permitted a remote pilot to control the target plane as though he were sitting in it and that an automatic pilot was not needed. The estimated budget totaled $77,500 which would cover the purchase of two Stearman-Hammond, JH-1 planes; the development of special mechanical gear for the target planes; installation of radio control gear in the target planes and in the control stations (two field control carts and two control planes); and the salaries of an engineer and a draftsman.

Curtiss N2C-2 Drone. (Author's collection)

This budget was exceeded by 15 percent because the delay in receipt of the Stearman-Hammond planes necessitated the prorotyping of two Curtiss training planes, N2C-2s by placing them on tricycle landing gear.

RADIO CONTROL OF AIRCRAFT PROJECT WAS INITIATED

On 9 September 1936, the CNO approved the plans of the officer-in-charge and the project got underway. In addition to the OinC's primary base of operations at the Naval Aircraft Factory (NAF) in Philadelphia, Pennsylvania, he was given a desk in the BuAer called the Special Designs Desk. This dual responsibility did much to prosecute the project at high priority.

The personnel involved in the project were as follows: At the NAF—Officer-in-charge, Lt. Cdr. D.S. Fahrney; Mr. William Wait, Aero Eng.; Mr. George Spangenberg, Asst. Aero Eng.; Warrant Officer S.E. Herbst, radio electrician and aviation pilot; Aviation Chief Machinist Mate (ACMM) Fred Wallace, Naval Aviation Pilot (NAP); ACMM Wm. Bowlin, NAP; Chief Radioman C.W. Bailey, NAP; Chief Radioman L.W. Hendrickson; ACMM L.E. Herzog; AMMIC L.B. McKeon; AMMIC H.O. Schultz; AMMCI H.E. Foster; RMIC F.E. Novak; RMIC J.V. Booty; AMMZC J.C. Rostien; AMMZC W.C. Kenefic; AMMZC N.N. LeMonte and AMMZC J.M. Wolfe. The group started off with Wallace, Bowlin, Hendrickson and Herzog, and the others came aboard as the project required additional personnel.

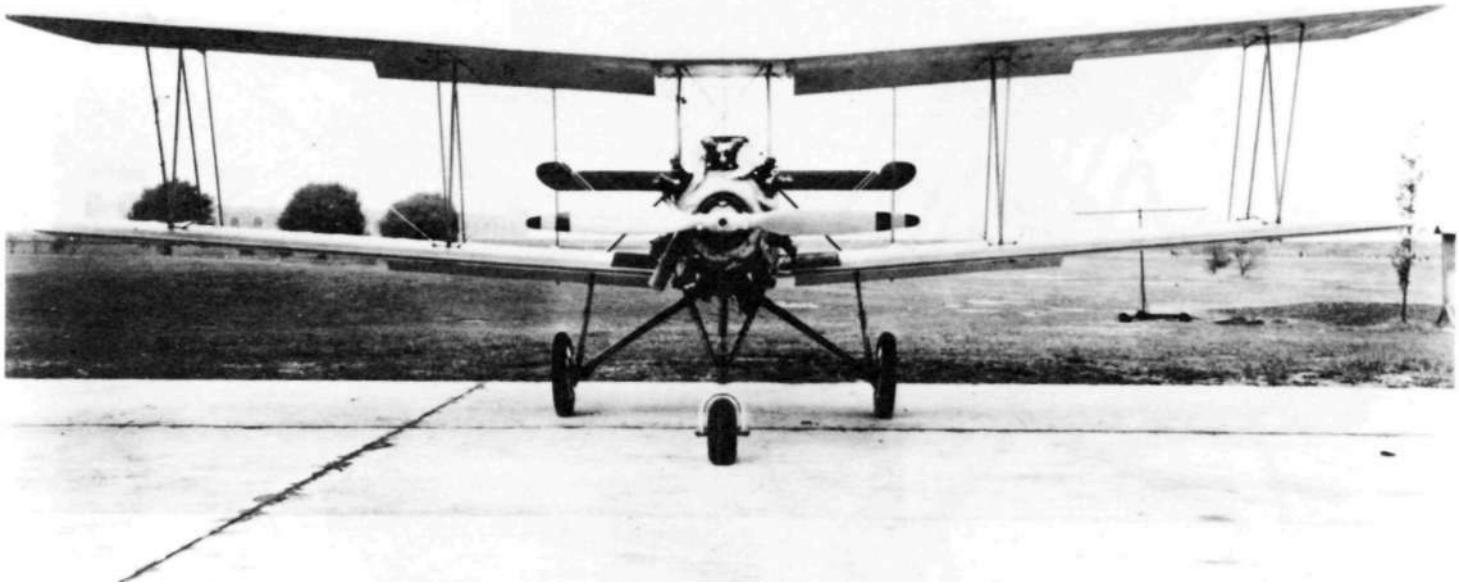
At the Naval Research Laboratory (NRL) at Anacostia, D.C., radio engineers M.H. Schrenk and L.C. Young, E.L. Luke and J.C. Link under the direction of Dr. J. Hoyt Taylor with C.B. Mirick as consultant.

The development of the radio equipment was concerned chiefly with the establishment of an oscillating circuit which when energized would send out a note or tone of modulated frequency over the selected carrier wave by the transmitter At the receiving end the tone would be picked up by the receiver and filtered out by another oscillating circuit similar to the one at the transmitter end and precisely responsive to it. These oscillating circuits were devised by the use of a vibrating steel reed which would give off a tone when forced to vibrate between the magnetic poles of two standard headphones. The transmitting end of the tonal production was called the modulator and the receiving end was called the selector. There were 12 distinct and individual oscillating circuits which permitted the assignment of two circuits for up and down aileron, two for up and down elevators, two for on and off throttle, two for on and off control of any desired instrument or control device (as flap controls or steering control on the ground), and a circuit to disengage the radio control gear instantly by the safety pilot. The rudder and ailerons were operated together so there was no direct rudder control. Thus, four circuits were available for future control applications. Standard stick or wheel control and foot rudder controls were used to activate electrical contacts which caused the radio control signals to be sent out.

Along in November 1936, the author discussed with Dr. Taylor, Technical Director of NRL, the selection of a code name which best described the radio-controlled aircraft target. Since the British called their target plane the *Queen Bee,* it was decided that the word *Drone* best fitted the career of a target plane, so that name was adopted and used in all subsequent correspondence and is still in use today.

The necessary hydraulic servos with control valves and electric solenoids were developed by the Radio Control Unit at NAF and installed in the test aircraft—first in an NT plane and later in two Curtiss N2C-2 training planes and two Stearman-Hammond JH-1 planes.

The development and fabrication of the essential equipment progressed so well at the NAF and the NRL that tests of an



Curtiss N2C-2 modified showing tricycle landing gear and flaps—the first guided missile. (Author's collection)

N2C-2 drone under radio control with a safety pilot were started on 7 October 1937. The author made the first takeoff and landing; followed by Herbst, Wallace and Bowlin controlling the Drone from a field cart. Next, tests were run with a radio control pilot in the control plane, a TG-2 torpedo plane. The field control pilot would take the Drone off, turn over control at around 200 feet to the control pilot in the front seat of the TG-2 plane. After maneuvering the Drone, the TG-2 control pilot would line the Drone up for the landing approach, turn control over to the field cart control pilot, who would make the landing.

Early in November 1937, the testing was moved to the Coast Guard Air Station at Cape May, N.J., because of the good overall field conditions and the steady breezes off the ocean. Furthermore, the station was not in a highly populated area and no air operations were conducted in the vicinity. By the 15th of November, many tests simulating a flight of the Drone without a safety pilot were carried out with each of the four pilots (Fahrney, Herbst, Wallace and Bowlin) becoming proficient in each of the required operating posts; as radio control pilot on the field cart or in the control plane; pilot of the TG-2 plane or safety pilot in the Drone.

The Officer-in-Charge decided that a first NOLO flight of the Drone could be attempted on November 15, and at 1350 on that date, an N2C-2 drone was taken off without a safety pilot, turned over to the TG-2 control at 200 feet altitude, flown for about 10 minutes and lined up for the landing. The field cart control pilot took over control at around 100 feet and made a fly-on landing that damaged the nose wheel causing the plane to skid along on its nose. The damage was slight and the plane was soon back in service.

FIRST SUCCESSFUL NOLO FLIGHT IN THIS COUNTRY

The next NOLO attempt was carried out on the 23rd of December using a Stearman-Hammond JH-1 Drone. The same technique as used on the November 15th NOLO flight was used, except the "fly-on" type landing was modified to that of a slightly stalled landing and it was to be negotiated close to the field control cart. Also a Sperry directional gyro had been modified and could be engaged by radio to hold the Drone on a precise heading.

The control plane took off first and when in position down wind from the Drone at about 300 feet altitude, the signal was given for the takeoff of the JH-1 Drone. The Drone took off smoothly under control from the field cart and when it reached an altitude around 200 feet the control was shifted to the control plane (TG-2). The control pilot carried out simple maneuvers for about 10 minutes and then brought the Drone down for a landing approach. When the Drone had descended to around 50 feet on the glide approach, the control was shifted to the field cart and a successful landing was made.

The test on December 23, 1937, was the first completely successful flight of a full-scale airplane in this country under radio control and without a human safety pilot. The control pilot on the field cart, who made the takeoff and landing, was Fred Wallace.

A form of automatic pilot was designed and fabricated by the NAF group with the greater "input" by Herzog (ACMM) who developed the unique carriage mounting, the follow-up gear and the photocell sensing device. This wing-leveling instrument was of inestimable value as it could be called upon by radio signal to bring the Drone to a level flight under any flight condition. All instrument modifications and fabrication of needed parts were carried out in the Instrument Laboratory whose director was Lt.(jg) Robert F. Jones. The technician under Jones who was most responsible for the Drone instrument work was Mr. George Shaefer.

PROJECT TRANSFERRED TO WEST COAST

After a number of demonstration NOLO flights at Cape May for the Chief of BuAer and other high-ranking officers of interested bureaus, it was concluded that the project could now be moved to the West Coast for antiaircraft tests by the U.S. Fleet.

Accordingly, the radio control unit received orders for the transfer to the West Coast and the movement of personnel and material began on 1 June 1938. By the early part of July, the move was completed. The personnel had now grown to 18 officers and men:

Lt. Cdr. D.S. Fahrney, OinC; Radio Elect. S.E. Herbst; (ACMM) Fred Wallace, NAP; (ACMM) W.M. Bowlin, NAP; (CRM) C.W. Bailey, NAP; (CRM) L.W. Hendrickson; (ACMM) C.E. Herzog; (AMMIC) L.B. McKeon; (AMMIC) H.D. Schultz; (AMMIC) R.E. Foster; (RMIC) F.E. Nowak; (RMIC)J.V. Booty; (RMIC) H.W. Grove; (AMMZC) J.C. Rostien; (AMMZC) W.C. Kenefic; (AMMZC) N.N. LeMonte; (AMMZC) J.M. Wolf. (RMIC) J.H. Purl was left at the NAF to supervise installation of radio control equipment in 12 N2C-2 planes being converted to Drones. The two TG-2 control planes were ferried across continent and the four Drones (two N2C-2s and two JH-ls) were shipped across by rail as well as the two field control trucks and necessary gear and spare parts.

The Officer-in-Charge had been sent ahead of the above movement in order to select a base for the operations. Fields in the San Diego area and on San Clemente Island were inspected and a level flat area of land on Otay Mesa south of San Diego was found to offer the requirements of safety (in the event of a malfunction in the control equipment), and remoteness from a populated area and from other aircraft operations.

FIRST DRONE FIRING PRACTICE

Since the Radio Control Unit was temporarily assigned to the VJ-1 Squadron of the Utility Wing of the U.S. Fleet, it was given the name of *Project Dog.* By the 10th of August, the Officer-in-Charge reported to CinC that the unit was ready to conduct the first firing tests. The aircraft carrier, USS RANGER, was selected by the CinC to carry out two firing runs. The practices were to simulate the firing by a screening vessel on a bomber passing over the ship and headed for the Fleet Center. Firing was to commence when the slant range was 4000 yards and to cease when the slant range reached 6000 yards.

The Radio Control Unit made rehearsal runs over the RANGER on August 15th and 16th using a safety pilot in the Drone. The sky parage was worked out as follows: at the altitude of 10,000 feet the No. 1 control plane took station one mile abeam of the Drone and the No. 2 standby control plane trailed the Drone at a two-mile interval. All control for the run was vested in No. 1 control plane and No. 2 would take over control if there were a malfunction in No. 1.

On 24 August 1938, the USS RANGER fired on the Drone with its starboard antiaircraft battery on the first run and the port battery on the second run. There were no bursts near the Drone and the unit was ordered to return it to Otay Mesa. Unfortunately, the RANGER had requested No. 1 control plane to open its distance abeam of the Drone during the second and last tuns. The increased distance and the smoke of the bursts of the shells, together with the failure of the wing-leveling device on the Drone during the climb to 10,000 feet, caused the control pilot to lose control and the Drone was lost on the return to base.

The agonizing reappraisal of the Fleet's antiaircraft effectiveness now began and it was more demanding following the tests carried out at Guantanamo Bay, Cuba, during the following winter. The generally accepted plan was to have all gunnery practices, especially antiaircraft, as stereotyped and devoid of realism as was possible in order to get a good score and thereby enhance a ship's standing. That this was the controlling factor is abundantly clear by a lament in the report of the USS RANGER.

"It was unfortunate that the Drone was unable to maintain a steady course and speed until the first burst." The CinC, Admiral C.C. Block, looked at it differently. "This maneuvering of the target presented a problem never before experienced when firing on an antiaircraft target sleeve, or when training on planes. Past analysis of the firing shows that the control personnel were unprepared for the problem presented, and were unable to accommodate their procedure to effectively handle it. This practice is considered to have been invaluable not only to the RANGER personnel, but also to the numerous other Fleet personnel (200 or more). It is expected that the practice will leave a lasting impression upon all who witnessed it and it has stimulated greater interest in the antiaircraft problem."

WORLD'S FIRST GUIDED MISSILE

In preparation for the dive-bombing tests that were planned against the USS UTAH (a radio-controlled target battleship), the Officer-in-Charge had his unit carry out dive tests on selected land targets on Otay Mesa from 10,000 feet. It was found that the control pilot at that altitude could, with visual guidance, direct the Drone accurately into near collision with the target. The runs were made with a safety pilot riding in the Drone. Later the proof that this was a prototype guided missile came in the NOLO dive tests against the USS UTAH.

On the 14th of September 1938, an N2C-2 Drone without a human pilot was taken off under radio control and flown to the USS UTAH'S firing area. A field control cart was placed on the deck of the UTAH to control the last part of the dive to keep the Drone from crashing on the ship. The control pilot in the TG-2 plane put the Drone in a dive from an altitude of 8700 feet. When the position angle was about 38° and after the Drone settled in the dive toward the ship the dive angle was 45°. The UTAH had a newly installed battery of 1.1 inch 75-caliber guns operating in a single mount. Two bursts of gunfire were fired and during the second burst, the Drone was hit and went out of control and crashed into the sea. The hit was apparently a fortuitous one because later in identical tests at Guantanamo Bay, Cuba, many dives were made on the UTAH by the target Drone and no hits were made. It is of interest to note that much importance was attached to the first UTAH firing off San Diego as indicating that a diving plane can be brought down easily when, in fact, that was not the case. It takes many tests to prove a point.

The dive-bombing attack by a target Drone on the USS UTAH on the 14th of September 1938 was historically the world's first guided missile prototype in that the Drone was a full-scale aircraft capable of carrying a bomb, was controlled remotely by radio, and was visually guided to the target by a control pilot at a safe altitude. This test fulfilled the author's request in August 1936 to Chief of Naval Operations that the Radio Control of the aircraft project be extended (after successful completion of a radio control of an airplane) to develop "aerial torpedoes (low horizontal attacks and diving attacks)."

It is necessary that the date for the evolution of a new and revolutionary weapon be exactly determined and documented. The official record will show that the first German guided missile was successfully tested on 18 December 1940. This missile

Curtiss N2C-2. (Harry Gann collection)

was an unpowered glide bomb, remotely controlled by radio and visually guided (it was designed and developed by Prof. Herbert Wagner) from an altitude of 2000 meters, flew smoothly to the target (a barn) and passed directly over the target close enough to be considered a hit. This test was executed two years and three months after the U.S. Navy carried out the dive tests on the USS UTAH.

Prof. Wagner's HS-293 missiles equipped with solid propellant rocket motors were used in combat in the Bay of Biscay on 27 August 1943 and sank or damaged several ships. Dr. Max Otto Kramer designed and developed the *Fritz X* missile which was a bomb with small wings and control surfaces, controlled by commands sent over a trailing wire that linked the falling missile with the mother plane. This missile sank warships in the Mediterranean from 9 September 1943 to 5 October 1943. The V-l "Buzz Bomb" was first introduced in combat on 13 June 1944 and the V-2 Rocket on 6 September 1944.

The author returned to the Naval Aircraft Factory at Philadelphia, Pennsylvania, after the completion of the dive test on the UTAH and turned the Drone target unit over to the Commander of the Utility Wing U.S. Fleet who placed it under VJ-1 Squadron with Lt.(jg) Robert F. Jones in command. Jones had assisted materially in the modification of instruments for the Radio Control Project while he was in charge of the Instrument Laboratory at the NAF and consequently developed a great interest in the project. When he was ordered to duty with the Utility Wing U.S. Fleet at San Diego, the author requested that Jones be given a temporary assignment with the Drone project and the request was approved. The transfer of the experimental Drone unit to a U.S. Fleet service unit called for a new designation, which became *Project Dog.* All the personnel of the experimental unit were transferred to the U.S. Fleet Service Unit, so this necessitated the organization of a complete new cadre of pilots and technicians at NAF to carry on the checkout of target Drones being modified at NAF for the U.S. Fleet, as well as continuing development work on higher performance target Drones and guided missiles.

In all the flight testing of the experimental Drones from March 1937 through the tests with the U.S. Fleet off San Diego in September 1938, the author and his four enlisted pilots alternated at the radio control stations (two in the field control carts and two in the control planes). Each became adept at controlling the Drone from the field cart for takeoffs and landings, and from the control plane for air maneuvers. Each took his turn as a safety pilot in the Drone, pilot of the TG-2 control plane, control pilot on the field cart, and control pilot in the TG-2 plane.

The CinC U.S. Fleet recommended to CNO that the Officer-in-Charge of the experimental unit, the author, be ordered to report to CinC for temporary duty and to remain with the target unit until the tests with the Fleet at Guantanamo Bay, Cuba, were completed during the winter of 1939. This was largely a consultant assignment as the operations were then under the command of Lt. Jones of VJ-1 Squadron.

U.S. FLEET FIRING TESTS ON DRONES

During the winter from 1 February 1939 through 30 March 1939, 17 vessels of the U.S. Fleet fired on Drone targets. There were no malfunctions in the equipment or handling of the practices by the *Project Dog* unit; however, no hits were made on the Drones in about half of the practices and several Drones survived with hits in wings or fuselages. Only two Drones were brought down by gunfire. This precipitated a second agonizing reappraisal of the antiaircraft defenses of the Fleet that resulted in redesign of both fire control and artillery systems. Fortunately, these target Drone tests were responsible for major changes in the defenses against bombing aircraft in time to be effective before our nation was plunged into war in December 1941. The CinC U.S. Fleet, Admiral C.C. Block, stated, "It is the well-considered opinion of the undersigned that the exercises with, and firing upon, the radio-controlled target airplanes have resulted in the greatest interest and advance in antiaircraft gunnery effectiveness since its inception in the Fleet. It is considered most fortunate that this condition should have been discov-

Great Lakes TG-2 torpedo plane, world's first Assault Drone—experimental. (Author's collection)

ered in target practice and not in an actual campaign."

U.S. ARMY AIR CORPS BECOMES INTERESTED

Representatives of the U.S. Army Air Corps, Capt. George Holloman, Capt. Gilbert Hayden and Mr. Hendricks of Wright Field witnessed radio-controlled flights at NAF on 4 February 1938. The Stearman-Hammond JH-1 Drone, with safety pilot, was controlled easily by Capt. Holloman in air maneuvers as control pilot in the TG-2 plane. He was pleased with the sensitive and instantaneous control of the Drone and the responsiveness of the Drone to the control impulses. Also he liked the way the Drone responded when the lateral stabilizing instrument, a modified Sperry Horizon, leveled the wings when it was activated on radio signal. When the target drone tests with the Fleet were scheduled for Guantanamo Bay, the Army Air Corps sent Capt. George Holloman and Lt. Rudolph Fink from Wright Field to witness part of the scheduled operations and to advise the Chief of the Air Corps, General H.H. Arnold, as to the adaptability of the radio control gear for Army uses. The two officers witnessed the ground control operations for the USS IDAHO firing on 16 March 1939, and made flights in the control planes for the USS PATTERSON practices on 17 March 1939. On their return to Wright Field their report recommended that the Army Air Corps initiate programs for development of radio-controlled aircraft targets and weapons. General Arnold, in April 1939, requested the Navy to supply the Corps with a TG-2 control plane, an N2C-2 Drone and a Field Control Cart. During the summer of 1939 all the above planes and radio equipment were delivered to the Army Air Corps.

Throughout the war years a strong, friendly and cooperative relationship existed between Holloman and the author and each kept the other abreast of all developments taking place in radio-controlled aircraft and guided missiles. Because of their mutual interest in the development of a revolutionary new weapon the terminology as well as the definition of the weapon was often discussed. Holloman suggested "directed," "dirigible" and "remote control" while the author urged the term "guided." This latter term was selected and from then on "guided missile" was used in all correspondence and in all discussions. The term persists to this day. Next, a definition was agreed upon which stated, "A guided missile is an air traversing vehicle which is guided from its launch until it hits the target."

GUIDED MISSILE DEVELOPMENTS INITIATED

The author returned to NAF in April 1939 from the temporary assignment with the *Project Dog* detachment at Guantanamo Bay and resumed his duties as Officer-in-Charge of Radio Controlled Aircraft. In addition to furnishing the Fleet with high-performance Drones (modified obsolete aircraft or new commercial planes) was the more intriguing conception of a flying missile that could be guided to its target beyond visual ranges. The design and development of such a weapon was now a very real possibility since we had the vehicle and could control it by radio and only a guidance system was needed. In the early studies for a remotely controlled weapon it was noted that Dr. Zworykin of RCA had proposed to the Bureau of Ordnance in November 1935 that an "electric eye" could be developed which would weigh about 50 pounds. BuOrd had no interest

in the proposal at the time so no development contract was negotiated.

In the meantime RCA had continued work on television and so the company was approached to ascertain the feasibility of developing a small TV transmitter to be carried on a missile and a small TV receiver to be carried in a control plane. The NAF personnel thoroughly investigated the possibilities with RCA personnel early in 1938 and BuAer authorized purchase and test of a small TV set on 14 October 1939. Experimental equipment procured on a contract dated 24 February 1940 was tested with good results during 1940 by NAF. In January 1941, the TV equipment was tested satisfactorily in an XOJ airplane. By the 4th of June 1941, the TV transmitter in a plane was producing pictures of such quality on the TV receiver in a second plane that the operator in the second plane could direct the first plane to pass directly over a designated target. The transmitter weighed 35 pounds with dimensions of 7.5 inches by 7.5 inches by 23 inches and the power supply weighed 35 pounds. The set transmitted a 325-line picture at 40 frames.

The author, having been ordered to duty in BuAer on 20 May 1940, was assigned as Head of the Special Design Branch which had cognizance over pilotless aircraft and guided missiles. A letter was prepared for Chief of BuAer's signature on 17 January 1941, directing NAF to carry out tests which would prove the feasibility of controlling a TV-equipped Drone into a collision with a target from a distant control station. Work had been underway as early as 22 March 1940 on a TG-2 torpedo plane equipped with radio control equipment and a radio altimeter that would enable the plane to fly at a selected low altitude above the water for torpedo release. When the tests of the TV guidance and the radio altimeter were satisfactorily completed, the design of a service weapon was the next step and this became the *Assault Drone* program.

In order to carry out this intricate and complicated program it was necessary to recruit officer personnel well qualified technically and professionally to handle the problems presented as well as possessing the interest in, and motivation for, the guided missile art. Two aviation cadets, who the author had met at the Naval Air Station in Pensacola, Florida, in 1936, were on flying duty with the Fleet and often visited the Drone base on Leeward Point, across the bay from the NAS Guantanamo, during the Drone operations in 1939. The cadets, soon to be ensigns, were Eugene R. Dare and Molton B. Taylor, and both professed a great interest in the Drone project and were desirous of becoming associated with the experimental phases of the Radio Control of Aircraft Program. Dare was assigned to duty with VJ-1 Squadron with additional duty in *Project Dog.* Taylor was ordered to duty at the NAF in 1940 and assigned to *Project Fox.* It will be shown how fortuitous these assignments were for the guided missile program.

In August 1942, Lt. Grayson Merrill was assigned as assistant to the head of the Special Design Branch of BuAer. Merrill's assignment was timely because of his proficiency in flying and his technical training in the electronics field. He possessed the vision and the zeal of a pioneer as well as strong and intelligent leadership. Merrill became the head of the branch when the author was ordered to duty at the NAF (which soon became the Naval Air Material Center) and the author was assigned as Commanding Officer of the Naval Air Modification Unit (NAMU). This unit had cognizance over all target Drone and guided missile design and development as well as all urgent modifications to combat aircraft.

The Commander of VJ-3 Squadron, Lt. R.F. Jones, in compliance with a directive by CinC U.S. Fleet, made certain tests to prove the practicability of directing a Drone visually toward a target from a control plane operating at a safe distance. The tests conducted in August 1940 proved that a Drone could be directed consistently through small puffs of smoke. The CinC, Adm. J.O. Richardson, forwarded the report by Jones to CNO with this comment: "This report is an excellent example of thorough and practical investigation of a technical problem with the tools at hand—the radio-controlled attack offers promise." The endorsement by the Chief of BuAer outlined the projects underway and showing great promise at NAF, for the development of a remotely controlled flying weapon; as a radio reflection type altimeter, radio-controlled automatic pilot and television guidance system.

The author in a report to BuAer on 16 December 1940, after visiting Army Air Corps bases, stated, "As far as can be determined the Navy has outstripped all countries in the development of radio control of aircraft and it now appears logical that the Navy should develop the first radio-controlled aerial torpedo. Its tactical applications are many and studies and experiments are warranted. A definite plan for its development can be submitted." The Chief of BuAer, Adm. J.H. Towers, in his letter to NAF on 17 January 1941, stated that "The Bureau is particularly desirous that the technique of operating offensive torpedo-carrying, radio-controlled aircraft in quantity be pushed to a conclusion, and that sufficient flight tests of aircraft television be carried out to permit recommendations of useful application for naval purposes." The Chief of BuOrd, Adm. W.H.P. Blandy, in a letter to CNO dated 15 April 1941, suggested that all efforts for development of radio-controlled offensive weapons be concentrated on the development of a torpedo plane Drone.

A very necessary piece of equipment for a successful torpedo attack by a Drone aircraft was the radio altimeter which could hold the Drone at a set low altitude for the torpedo release. Late in 1938, a young electronics engineer, R.C. Sanders, joined the RCA company and was put to work under Dr. Irving Wolff on the radio altimeter. On 29 January 1941, the radio altimeter was demonstrated in a flight for naval personnel. The equipment gave a very successful performance under the expert handling of Sanders. It was concluded that the radio altimeter would fulfill the rigid requirements set down for a torpedo plane assault Drone.

Now that the television guidance equipment, the radio-controlled automatic pilot and the radio altimeter were conclusively proven, the next step was to incorporate them in a TG-2 assault Drone.

The CNO directed in March 1941 that a target Drone squadron be organized on the East Coast to give services to the Atlantic Fleet. This squadron became VJ-5 on 3 May 1941, and Lt. R.F. Jones became the commanding officer. Jones brought the key personnel with him from VJ-3 and this comprised most, if not all, the pilots and technicians in the pioneering group that developed the first Drone at the NAF. On 9 July 1941, Jones submitted a plan for the development of a radio-controlled fighter aircraft which could be directed into a large enemy bomber formation and exploded, which was called an "aerial ram." On 8 October 1941, CNO directed that the development

proceed under the direction of VJ-5 and the directive was broad stating "to develop, test, and operate radio-controlled offensive weapons and to train personnel in their use." This work was competitive with, and in duplication of, the research and development projects at the NAF and at NRL. It was proved later that an operating unit, much involved in supplying services to the Fleet, lacking laboratory facilities, shop facilities and test equipment, cannot carry out a highly complex experimental program. Two F2A-3 fighter planes and one pilot were lost in the tests and none of the equipment developed was later used in the Assault Drone program.

SIGNIFICANT PROJECTS IN RADIO CONTROL OF AIRCRAFT

As stated previously one of the early pioneers who joined the Drone program at Guantanamo Bay in 1939 was Cadet Eugene R. Dare. He served with the *Project Dog* unit until it became Squadron VJ-3. Late in 1940 Lt.(jg) Dare was ordered to BuAer as the author's assistant in the Special Design Branch. Dare was given temporary orders to command a unit of *Project Fox* at the NAF to carry out Drone target practices with the Support Force of the Atlantic Fleet in March of 1941. These Drone operations were skillfully and effectively carried out by Dare as were projects to test the effectiveness of the self-sealing gasoline tanks installed in a Drone and fired upon by fighter aircraft. Drones were also used to test the radio proximity fuse (variable time VT fuse) developed at the Applied Physics Laboratory and installed on shells fired at the Drones. In 1942 Lt. Dare was ordered to duty at NAF because of his unique qualifications as a leader in the radio-controlled aircraft field and because of the expansion of activities in this category at that station. While at NAF he carried out numerous tests of great significance to the overall program; as testing the first Assault Drone designed and manufactured at NAF (the TDN-1); testing a BG-1 plane rigged as a glider; testing the first DR-1 Assault Drone; and the structural flight testing under radio control of the F6F, the F40-1 and SB2C-1 airplanes.

The work at NAF on the TG-2 torpedo plane was progressing so well under Cdr. W.P. Cogswell, as OinC of Radio Controlled Aircraft, and his able assistant, Lt. M.B. Taylor, that by 8 October 1941, the NAF reported that tests indicated a realistic service trial could be carried out. In addition to the use of television for guidance, other projects were underway at NRL and NDRC to develop radar guidance systems. The Chief of BuAer stated in a letter dated 15 October 1941 to CNO, "On 13 March 1941, this bureau initiated a project dealing with the direction of one or more radio-controlled Assault Drones through the medium of radar. Certain units of equipment are now under test and development at the Naval Aircraft Factory, the Naval Research Laboratory, and the National Defense Research Council." The CNO replied on 28 October 1941 that "Progress in the Assault Drone program is a matter of great interest to the Chief of Naval Operations, and to the service at large. It is considered that explorations are being conducted along lines dictated by possible practical service applications." The Chief of BuOrd stated that torpedo dropping tests could be carried out in the Newport-Quonset area when the Drone was ready. At a BuAer and BuOrd conference on 24 October 1941 (BuOrd representatives were Captains Shumaker and Schuyler and Commanders King and Schoeffel—BuAer representatives, Commanders Stevens and Fahrney), the service tests were planned and it was further suggested that 100 obsolete TBD planes be assigned for modification to Assault Drones and that when SBD planes became obsolete they should be assigned to the program.

On the 29th of November 1941, BuAer completed the preliminary design of a special Assault Drone that could be manufactured outside the regular aircraft industry now heavily involved in producing planes and engines and related equipment for Great Britain as well as building combat equipment for the air arms of the Army and Navy.

CNO TAKES CONTROL OF ASSAULT DRONE PROGRAM

On 7 December 1941, Japan made the attack on Pearl Harbor and our country went to war, so the plans to use obsolete aircraft for Assault Drones were shelved, as every available plane was needed for combat. The use of an Assault Drone of special design was therefore given high priority for earliest development.

On the 15th of December 1941, another important figure, Captain Oscar Smith, entered the Assault Drone program as a result of a letter which he addressed to the CNO from his command at the Atlantic Fleet Base at the Naval Operating Base, Norfolk, Va. His letter was concerned with the use of radio-controlled aircraft in offensive applications against the enemy. As he stated his thesis, "We need no suicide squad to dive torpedo laden airplanes into the sides of enemy ships. Let a simple type of radio control be placed on a plane, and we have a suicide pilot who will not falter, but will obey orders of a controlling plane, and will not hesitate to fly within 100 yards of the enemy ship before dropping a torpedo." He added further "at a distance of not less than 50 miles from the objective, the pilots in the robot planes will place them under radio control and will parachute to the water below, for a prearranged pickup." The Chief BuAer endorsement of 7 January 1942 outlined all the Assault Drone projects that were actively pursued by the *Project Fox* guided missile unit at NAF.

Capt. Smith became restive when no reply was forthcoming to his letter of December 15, 1941; so on 7 February 1942, he addressed a letter to CNO Adm. Stark requesting that he be appraised of the action contemplated on his plan for use of aerial radio-controlled torpedoes. He requested further that he be placed in charge of the weapon project and added, "My request for supervision over the development should not be rejected because I am not an aviator. I can bring more experience and as much common sense to the subject as any aviator, and an equal or greater enthusiasm. There are few aviators who flew before my first flight in 1912, and none who has had greater interest in the adaptation of aviation to naval warfare."

About mid-February 1942, Smith was assigned to duty as Director of the Plans Division in the office of the CNO. At an early date he personally investigated the activities of Projects *Dog* and *Fox* and determined that the tests by *Project Fox* on a Drone equipped with TV guidance held the greatest promise for service use as a combat weapon. In his report, 9 March 1942, to CNO he stated, "In my opinion the urgency of our situation and the possibilities of this weapon are such as to make it essential that regular peacetime developments be shortened and the Drone [TV guided] be hurried along for combat use."

Impressed by Smith's report, the Vice Chief of Naval Opera-

tions, Adm. F.J. Home, authorized Smith to arrange tests which would prove the weapon's qualifications for hitting accurately moving targets.

FIRST SURFACE-TO-SURFACE GUIDED MISSILE

On 1 April 1942, the NAF *Project Fox* was moved to Quonset Point, R.I., to carry out the prescribed test of a torpedo attack on a maneuvering destroyer by a TG-2 torpedo plane Drone guided by television. On the 9th of April 1942, the *Project Fox* team was ready for the great trial with Lt.(jg) M.B. Taylor at the Drone control station in the JRB control plane piloted by Ens. S.E. Herbst. The destroyer, USS AARON WARD (DD483) was the target ship which steamed parallel to the torpedo range off Narragansett Bay. The TG-2 torpedo plane Assault Drone, without a human aboard, was taken off at 1113 hours with its torpedo set to run at a depth of 38 feet so it would pass under the destroyer. The wind was from 90° at 10 knots, sky overcast with visibility of 15 miles and the sea with a moderate swell running. The TV camera in the Drone picked up the target when it was four miles distant and the Drone was flying at 85 knots speed at an altitude of 150 feet. On the approach of the Drone the destroyer turned north from an easterly course and increased speed to 15 knots. The control plane was eight miles from the target when the Drone control pilot. Taylor, directed the Drone to the torpedo release position about 300 yards astern of the destroyer. He released the torpedo by radio and it passed directly under the full length of the target.

This was a significant achievement as well as being an historic event, in that it heralded and forecast weapons that would revolutionize warfare. Furthermore, it constituted the first surface-to-surface guided missile attack ever conducted and with noteworthy success. Weaponeers down through the ages had sought a missile that could be launched from a safe distance and guided unerringly to a selected tatget—there off Narragansett Bay on 9 April 1942, such a missile was successfully demonstrated.

In the meantime, units of the Fleet (cruiser and battleships) had fired on target Drones simulating torpedo runs and in one practice four runs were made before the Drone was destroyed, indicating that in a multiple Assault Drone attack some would reach the torpedo release point.

The NAF *Project Fox* unit carried out another successful test of historic importance on 19 April 1942. The test was to prove the practicability of crashing an Assault Drone into a moving target. A BG-1 Drone equipped with a sensitive radio altimeter, radio control, and television guidance was selected to crash into a battleraft towed at eight knots. The Drone was taken off by radio from Liveley, Va., by a field cart control pilot and turned over to the control pilot, Lt. M.B. Taylor, in a JRB plane. The Drone picked up and relayed a good television picture of the target when five miles distant from it the control plane turned away and was 11 miles distant when the Drone crashed the target raft. Taylor was able to maneuver the Drone by watching the television screen and directing it into a collision course by radio. The Drone crashed through the upper forward central portion of a battleraft and fell into the water beyond.

The test on 9 April and the test on 19 April 1942 proved conclusively that the guided missile had arrived and that the U.S. Navy was the first in the world to originate and develop it.

Early in May, motion pictures of the tests, described above, were shown for the Commander-in-Chief (COMINCH) Adm. E.J. King and for chiefs of the interested bureas of the Navy Department. Oral presentations were provided by Captains Smith and Fahrney. Immediately following the presentation, Adm. King assigned Captain Smith as Officer-in-Charge of *Project Option* (which absorbed *Project Dog)* with a basic directive to develop a service weapon from the experimental guided missile (Assault Drone) and to ready the weapon for combat employment in quantity at the earliest practicable date. Smith was directed to function under COMINCH's Aide for Readiness, R. Adm. W.A. Lee. The ultimate responsibility for design, development, and procurement of the weapon was to remain in BuAer whose chief was R. Adm. Towers.

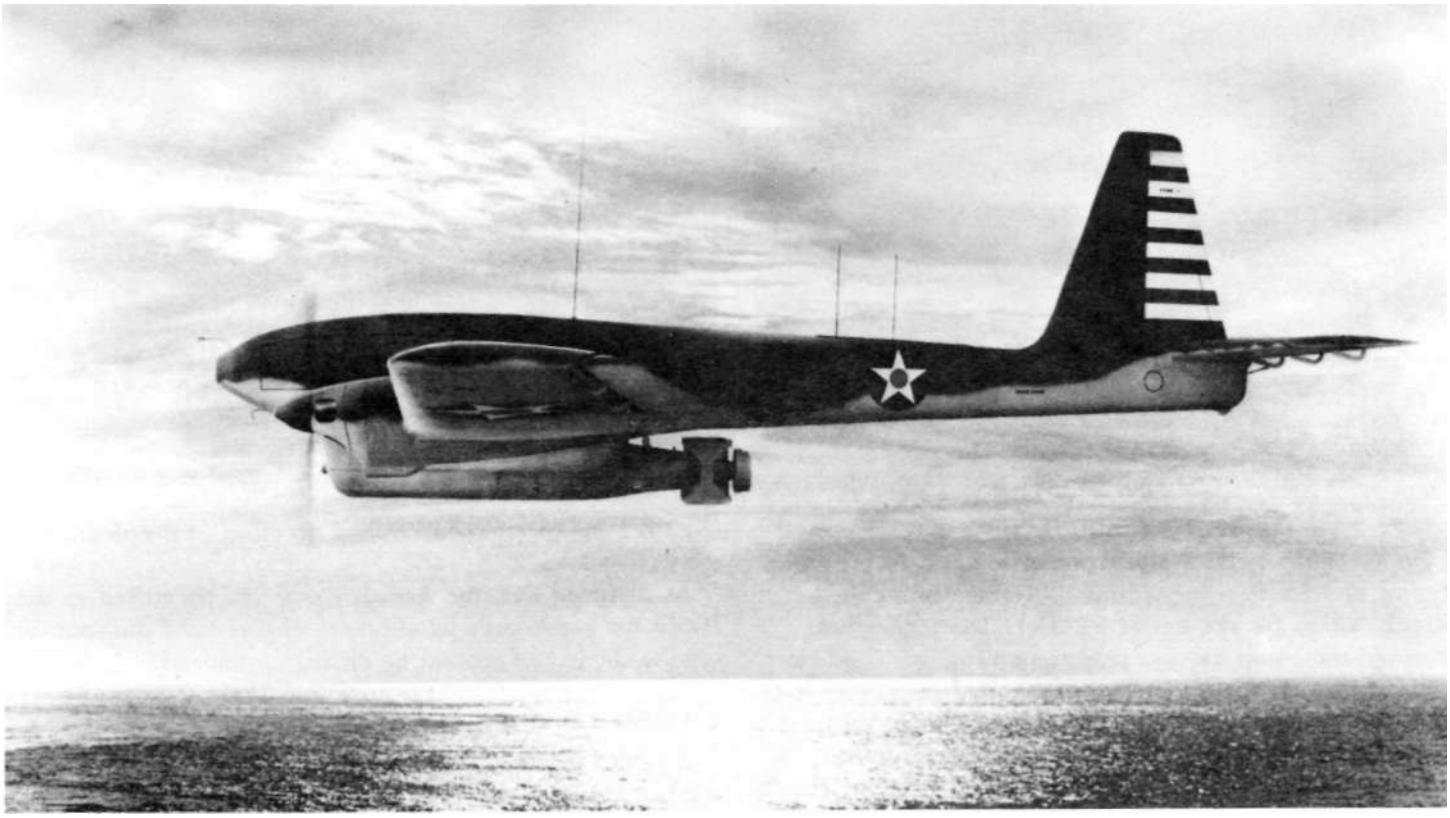
Friction soon developed between Smith and Towers as a result of the magnitude of the program prescribed by Smith and his staff and orders from CNO to carry it out. Prior consultations with BuAer were not made to determine the impact on urgent requirements of high priority from aviation activities in the combat areas. Towers was very much opposed to a plan to place a new weapon into mass production before it had been proven on a small scale in combat. Such a trial would prove its effectiveness as well as to determine the needed performance and logistic requirements. Plans for early combat trials had been formulated by the author and the Assistant Director of the Engineering Division in BuAer, Capt. L.C. Stevens, and were approved by Admiral Towers. The combat tests were to be carried out as soon as the Assault Drone tests described above were completed. It was determined that the feasibility of the weapon could be ascertained in England where our naval forces requested a weapon that could be flown into the German submarine pens along the French coast; and in the South Pacific came a request for a weapon to fly into the Japanese stronghold at Abdul. When the guided missile effort for the Navy was placed under Capt. Smith in CNO, the BuAer's plans for early combat tests were dropped.

The initial directive from CNO on 22 May 1942 requested BuAer to provide and train personnel for 18 Assault Drone squadrons, provide 162 control planes, and provide 500 Assault Drones with 500 more in reserve. In the analysis of the problem BuAer planners found that a program of this magnitude would require 1300 naval aviators and 8700 men; and to achieve a production rate of 300 to 500 Drones per month, an initial contract for 5000 would be necessary. Since manpower and industrial capacity were already pressed to the limit to provide the sinews of war, this further drain on the nation's resources demanded that the program be greatly reduced. The Chief of BuAer requested on 29 June 1942 that no more than 500 Drones be manufactured and CNO approved the request and suggested that the 500 Drone program consist of the following:

One hundred TDNs, 200 TDRs, 100 TD2Rs, 100 TD3Rs (TDNs designed and manufactured by NAF, TDRs by Interstate Aircraft Co.).

On 10 November 1943, a conference was held at the headquarters of Commander in Chief (CinC) U.S. Fleet, Adm. Chester Nimitz, in Hawaii to discuss the future employment of Assault Drones in the Pacific Theatre of War. Present were Adm. Nimitz, V. Adm. Towers (now Commander Air Forces Pacific), V. Adm. Newton, R. Adm. McMorris, Capt. Forrest Sherman, and Commodore Oscar Smith. The following conclusions were reached relative to the introduction of guided missiles into combat:

(a) Must be shown to have advantages over weapons in use.



Interstate TDR-1 Assault Drone with torpedo. (Author's collection)

(b) Its method of employment must have been determined.

(c) Speed and maneuverability of the Drones (TDR-ls) should be increased—slow speed mitigates against usefulness.

(d) Recommend that combat Drones of high speed and maneuverability be developed and specifically recommend that SBDs (dive bombing planes) if suitable and available be converted to Drones.

These recommendations effectively closed the door on the utilization of the TDR-ls in combat even though Smith strongly supported their use under low visibility conditions or in concert with regular bombing and torpedo attacks. He pointed out that objectives could be hit with greater accuracy and certainty with less hazard to our attacking force and at less cost than any other weapon available at the time.

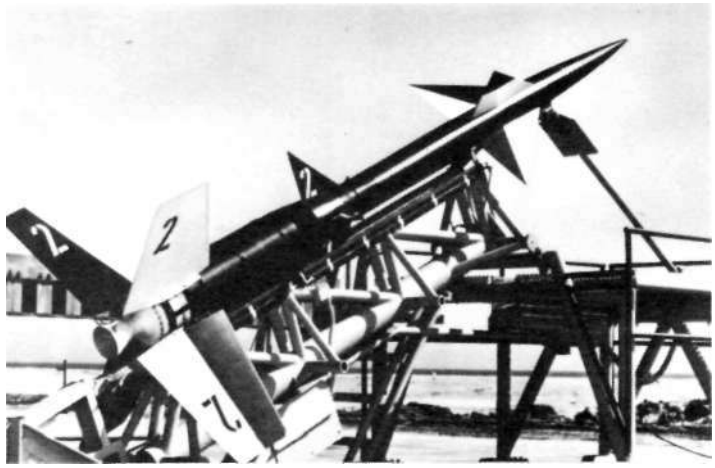
Vice Adm. Towers stated that the heavy demands on every air facility in the Pacific to supply conventional weapons to carry on the war made it unwise to give any space or any support for experimentation with an unproven weapon like the Assault Drone. Admiral Nimitz, in his report to Admiral King dated 25 November 1943, stated, "While deeply interested in the development of new weapons of this type, he [Nimitz] lacks carriers, landing fields and other facilities to try out unproven weapons."

Admiral Nimitz and Admiral Towers had recommended the conversion of SBD airplanes to Assault Drones but the Chief of BuAer was opposed to any further prototyping of this type until combat experience with the TDR-1 indicated a need. Admiral King again ordered Commodore Smith as Com SAT FOR to report to CinC Pac and arrange a combat trial of STAG-1 with TDR Drones and TBM control planes. The latter part of January 1944 Smith arrived in Pearl Harbor and found that Admiral Towers was opposed to the employment of the Assault Drones in any operation whatever. Admiral Spruance, Commander of the 5th Fleet, was at Pearl Harbor at the time planning the attack on the Marshall Islands and he was willing to give STAG I a trial. He suggested that, immediately after the Consolidation of the Marshalls, STAG-1 with SAT FOR staff could be moved to one of the airfields in the Gilbert Islands and be staged forward to Majuro to assist in the attack on Eniwetok late in May 1944. The suggestion by Spruance was approved by Nimitz and King. Unfortunately, for the guided missile, the Marshall Islands' campaign proved so successful that the date of the attack on Eniwetok was advanced and this made it impossible to transfer STAG-1 overseas in time to join in the campaign. A combat opportunity of prime importance to the guided missile program was lost.

At the above conference (January 1944), Admiral Towers again pointed out that the war in the Pacific had evolved from a static condition to a war of fast movement from island to island. Conventional air arms were adequate to support the highly successful operations and available in ever-increasing numbers to satisfy the commanders in the forward combat areas. Under these conditions it was not advisable to experiment with a weapon of unknown combat potential. Had the Assault Drone been tested when the war was static in Europe and in the South Pacific, its effectiveness could have been evaluated and its further development indicated before going into mass production.

In February 1944, Admiral King (COMINCH) and Admiral Home (CNO) reviewed the objections to the employment of the STAGs in the Pacific and on February 24th COMINCH directed CinC Pac as follows: "My conclusion is that experience must be gained deliberately and without delay in order that we may be guided in our preparations for the time when the defeat of Germany may make large numbers of long-range *Fortresses* and *Liberators* available for use as Drones, with B-29s as control planes. It is necessary that you take action to provide early test of this weapon with STAG-1 in Central or South Pacific."

Sat guided missile. (Author's collection)



Lark surface-to-air guided missile. (Author's collection)

On 11 March 1944, Smith reported to CinC Pac, Admiral Nimitz, and Smith requested the assignment of a CVE (small aircraft carrier) for the use of STAG-1. The request was not approved and Smith was directed to report to CinC Third Fleet, Admiral Wm. F. Halsey, Jr. Smith reported to Halsey on 17 March 1944, and was directed to report to Commander Aircraft South Pacific, R. Adm. E.L. Gunther, who recommended by dispatch on March 18 that STAG-1 be transferred to the Russell Islands. It was not until 18 May 1944 that ships could be provided for the move. All units arrived in the Russell Islands by 12 June 1944.

ASSAULT DRONE OPERATIONS IN SOUTH PACIFIC

On the 30th of July, with Admiral Gunther as a witness, four TDR-1 Drones made attacks on a beached Japanese Merchant Ship obtaining two direct hits and two near misses. The control planes never approached closer than seven miles to the target. Commodore Smith was certain that the motion pictures of these tests would convince ComAirPac, Admiral Towers, of the combat readiness of STAG-1 and therefore a combat assignment. He turned the command of STAG-1 over to his deputy, Cdr. R.F. Jones, and departed for Pearl Harbor. Smith found that regardless of the test evidence of reliability and accuracy of the weapon, there was strong official disinterest in the project because of its experimental nature and that STAG-1 would soon be returned to the States. After imparting this discouraging information by dispatch to Cdr. Jones, Smith proceeded to Washington to report to COMINCH.

Jones was determined to carry out Assault Drone tests against enemy installations before the return of STAG-1 to the States and he persuaded Commander Aircraft Northern Solomons, Brig. Gen. Clauss Larkin, USMC, at Bougainville to request ComSoPac to delay the departure for 30 days so that the combat tests could be carried out. ComSoPac granted the 30-day extension and between 27 September and 26 October 1944, numerous strikes against Japanese installations in the Bougainville and Rabaul areas were made. Of the 46 Drones launched, two were lost due to radio interference, seven were lost to material failures and 37 Drones reached the target area and launched attacks. Many of the latter were opposed by medium to intense anti-aircraft fire and three were shot down. At least 24 Drones executed attacks on the selected targets with satisfactory to excellent results. The attacks were made on "bypassed" pockets of enemy resistance and therefore had little if any effect on the progress of the war.

As it turned out, the Assault Drone project arrived in the Pacific too late to get a significant combat test and this contributed to the lack of support by the high command.

BU ORD'S BAT MISSILE

A guided missile that did get a better reception and tests in a combat area was the BAT missile developed by the Navy's Bureau of Ordnance. This was an unpowered glide-bomb with a self-seeking radar guidance system. The Officer-in-Charge of the developmental project was Lt. Cdr. D.P. Tucker who was responsible for the basic planning and overseeing of the design considerations. The project was motivated by an urgent requirement to develop a missile which could be launched from an airplane and home on a surfaced German submarine—many of which were operating off our shores. The project got underway in April 1942, using a small glider vehicle designed and developed by Dr. Hugh L. Dryden of the National Development and Research Committee (NDRC) who had been working on a glide bomb for the Army Air Corps. The radar homing equipment was designed and developed by the Radiation Laboratory at M.I.T. and the Bell Laboratories continued the development, testing and packaging for mass production. Drop tests on 22 December 1944 proved the effectiveness of the Bat missile and it was determined that large-scale production could proceed and that combat employment could be planned.

The Bat missiles were tested in combat early in 1945 in the Pacific War Theatre near Japan by three privateer patrol squadrons. They achieved limited success under very adverse circumstances; but on the whole the introduction of this very complex missile was creditable. An interesting feature of the program was the role that Cdr. Tucker played in it. He not only invented the weapon, but also supervised its design, development and testing. After the missiles were coming off the production lines, he went to the forward combat area to supervise the installation of the weapons on the patrol aircraft. Wholly dedicated, he flew on three combat missions as the missilier and personally launched his missile against the enemy. The Bat was the world's first self-seeking, radar-equipped, guided missile.

The Germans lost practically all of their combat air capability late in World War II, as a result of allied bombings and aerial engagements, forcing them to place more and more emphasis on missiles as indicated by the employment of the V-l Buzz Bomb

Douglas F3D-2M with *Sparrow* missiles. (McDonnell Douglas via Harry Gann)

and the V-2 Rocket. These surface-to-surface directed missiles were preceded by the employment in combat of the true guided missiles in the air-to-surface category. Dr. Wagner's HS-293 television guided missile and Dr. Kramer's *Fritz X* with trailing wire equipment. These latter missiles could not be employed, of course, after aircraft could no longer take to the air to carry them. A far-reaching program on a vast scale was underway to develop guided missiles in all four categories which were destined to replace tactical and strategic conventional aircraft. The broad expansion of this activity included many projects to destroy aircraft by missiles launched from aircraft or land bases and bombing missiles which could be launched from the air, the sea, or the land. Had the war lasted six months longer, German guided missiles would have wrought a significant change in the fortunes of war.

BU AER POSTWAR PROGRAM

The author returned to Washington from duty in the Pacific on 30 September 1945, and was assigned to duty in BuAer as head of the Special Design Branch, which soon became the Pilotless Aircraft Division, with responsibility for all guided missile and target Drone design and development. This branch had been headed by Cdr. Grayson Merrill during the period the author was on duty at NAF (one year) and in the South Pacific (18 months).

Because of the previously stated lack of interest in, and support for, a comprehensive guided missile program in BuAer (as a result of the general collapse of its war effort in the field), it was felt that a year's study of all phases of missile development was necessary. This study would lay the groundwork for a sensible and practical guided missile program that could best fulfill the future combat requirements of the Navy. Cdr. Grayson Merrill was assigned the chairmanship of a committee to make a thorough study of American, German and English developments in the field and to recommend a program for the future development of guided missiles by BuAer. This study was completed on 15 December 1945, and was called *Study of Requirements for Pilotless Aircraft for Fleet Use in 1950.* On 28 February 1946, the document was approved and formed the basis for missile studies by government and industrial agencies. Out of the 12 studies financed by BuAer and awarded to aircraft companies only six missile developmental contracts were negotiated.

THE FIRST SURFACE-TO-AIR GUIDED MISSILE

The Japanese adaptation of an expendable human being as the guidance system in a dive bomber, called the *Kamikaze,* caused the BuAer to accelerate the development of a surface-to-air missile to deter the *Kamikaze,* The initial planning on the deterrent missile was carried out by Cdr. Grayson Merrill of the Special Design Branch after a careful analysis of the requirements and the state of the art at the time and the practical early extension of that art. Much information was gleaned from the *Gorgon* projects being developed at the NAF. During October and November 1944, the missile was evolved in the BuAer drafting room and was given the code name *Lark.* The *Lark* project was reviewed and development recommended by the Services Jet

Propelled Missiles Board on 6 February 1945, and two days later CNO authorized BuAer to proceed at high priority with the development.

On the 21st of March 1945, a contract was made with the Fairchild Engine and Airplane Corp. to develop and manufacture the airframe and on 21 June 1945, Consolidated Vultee Aircraft Corp. (CONVAIR) was given a similar contract. The Raytheon Manufacturing Co. had been working on a radar homing system for the Assault Drone program so that company was asked to develop a homing system for *Lark,* called the AN-APN-23. A mid-course guidance system selected was a Naval Research Laboratory beam rider. A passive radar homing system by NRL and Fairchild-Ranger was also used.

Tests of the two *Lark* missiles were carried out at NOTS Inyokern and at NAMTC Point Mugu. By July 1948, *Lark* missiles were launched from the Navy's guided missile vessel, the *Norton Sound.* On 13 July 1948, it was decided at a conference of BuAer between contractor and BuAer representatives that Fairchild-Ranger would concentrate on the passive radar homing system and Convair on the use of mid-course beam rider and the Raytheon radar target seeking homing system.

Before the BuAer surrendered the surface-to-air missile field to BuOrd in exchange for dominance in the air-to-air field, the excellence of *the Lark* developmental program was outstandingly demonstrated. On the 13th of January 1950, a *Convair Lark* with a Raytheon FM homing system made the world's first interception of an airplane in flight. The historic flight was made after a launch from the Naval Air Missile Test Center (NAMTC) at Point Mugu, Calif., and the *Lark* intercepted an F6F fighter plane Drone.

FIRST AIR-TO-AIR GUIDED MISSILE

The author initiated the development of an air-to-air missile at the NAF around the middle of 1940 called the *Gorgon* program. Several designs of airframes and several power plant systems were carried through the ground and air-launched phases from 1943 through 1945. The air-to-air *Gorgon* missile with liquid rocket power plant could reach speeds of .9 Mach number but this was too slow to make attacks on jet aircraft that were coming into use after World War II.

The study program had outlined the characteristics for a high-performance, air-to-air missile, so in May 1946 the Sperry Gyroscope Co. was asked to study the problem and submit a proposal for the design and development of a radar beam riding missile. During May 1947 BuAer gave Sperry a contract to develop the missile and Sperry subcontracted the airframe to the Douglas Aircraft Co. The program was given the code name *Sparrow.* Flight testing began at NAMTC, Point Mugu, on 24 August 1948, and many successful launches were made during 1949.

The world's first intercept of an airplane in flight by an air-launched guided missile occurred on 3 December 1952. On that date, a *Sparrow* missile launched from an F3D airplane, piloted by Cdr. C.C. Andrews, intercepted and destroyed an F6F fighter Drone.

The success of the *Sparrow* project is measured today by its expansion into a family of air-to-air guided missiles and its employment on service combat aircraft of the U.S. Navy. The *Sparrow* missiles have not only performed splendidly but have been instrumental in selling supersonic guided missiles to the air arm of the U.S. Navy.

CONCLUSION

In retrospect, it is evident that Commodore Oscar Smith's Assault Drone program, after a monumental expenditure of effort and funds, was denied a significant test in a combat area. This resulted in a severe setback for the Navy's guided missile aspirants from which it took months to recover. On the other hand, the opposition to such a test by ComAirPac, Admiral Towers, and his staff was perhaps valid when we consider the low performance of the TDR Drone and the fast movement of the war at the time the Assault Drones were ready for a combat trial. The delay of two and one-half years in testing a new and promising weapon in combat found the Assault Drone placed in the hands of operational planners who were unresponsive to the novelty and potential value of the weapon, mainly because conventional weapons were everywhere sweeping their wielders to victory. Moreover, these planners were unwilling to give a wartime test to the Assault Drone because the target opportunities had passed almost a year earlier.

In summary, it should be noted that the Navy's pioneers in the field of guided missiles took great pride in the knowledge that their efforts laid the groundwork for the vast expansion and effectiveness of the art as it exists today. The rudiments of remote control and guidance, so vital to missile and space programs today, were conceived and developed in those early guided missile programs, as well as vehicles powered by turbo jets, and by liquid and solid rocket motors. Upon this initiatory base of technical research and experimentation, in which the U.S. Navy played the stellar role, stands the nation's enormous guided missile program today as well as the ultra-complex and awe-inspiring achievements in space technology.

ABOUT THE AUTHOR

Admiral Fahrney has earned the title as the "Father of the Guided Missile" as a result of development of the first guided missile in the world under his leadership and supervision. The successful demonstration of the control and guidance of an air-traversing vehicle was carried out in September 1938. fully two years before any other comparable development. Appointed as a midshipman in the summer of 1916. Fahrney was graduated from the U.S. Naval Academy in June 1919 (class of 1920) and after battleship and destroyer duties reported to the Naval Air Station. Pensacola, Fla . for flight training in 1923. and won his wings in the fall of 1924. He qualified for landings on our first aircraft carrier, the *USS Langley,* and made the first powder catapult takeoff in a Loening amphibian from the *USS West Virginia* in 1926. He reported to the postgraduate school at Annapolis in 1928 and received his Master of Science degree in aeronautical engineering from Massachusetts Institute of Technology in 1930

After duties on the *USS Wright* and *USS Lexington,* he was selected as a member of the aeronautical engineering duty only corps (AEDO) of the Navy in 1935. The Chief of BuAer assigned him as Officer-in-Charge of Radio Controlled Aircraft in 1936. The first fully successful radio control of a full-scale airplane (the Stearmah-Hammond, JH-1) was carried out on 23 December 1937 under his direction. The first guided missile, an N2C-2 Drone, under radio control and visual guidance, was tested in dives on the *USS Utah* in September 1938. The first guided missile, a TG-2 torpedo plane, under radio control and TV guidance, was tested successfully on 9 April 1942. Other notable firsts. the *Lark* and *Sparrow* tests came later

Admiral Fahrney was the first Commander of the Naval Air Missile Test Center, Point Mugu, Calif., and was serving in that billet at the time of his retirement from active duty in 1 950. He prepared a history of guided missiles on a personal services contract from BuAer in 1953, completing the contract in 1955. He was the senior member of a board that selected the site for the BuAer test facility now known as the Naval Air Test Station. Patuxent, and he and Capt. C.H. Shildhauer laid out the station's facilities. He was the senior naval member of the board that selected the long-range proving ground for Army. Navy and Air Force testing of rockets and missiles at Naval Air Station, Banana River, Fla., and Cape Canaveral—now NASA's space facility.