More Bats

Family Tree & History of the ASM-N-2 BAT Glide Bomb

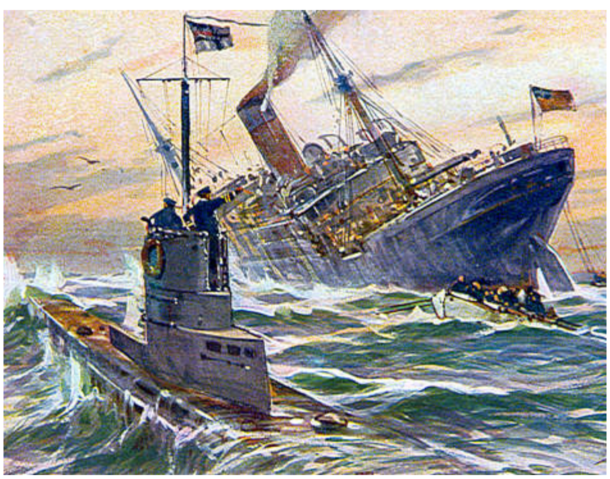
Scott C. Pedersen

NOTE: This is very much a work in progress and is a teaser for book project that is nearing completion. The material herein is a but small fraction of those archival materials that exist in my collection. Nevertheless, further information is requested from Aircrews and personnel who have had experience with these systems. Additional photographic contributions are appreciated!

First publication - Pedersen & Siegfried, 1996, BRN 37:42-48
Update/move to new domain completed April 20, 2009

Last edited 26 November, 2009

This page is GRAPHIC intensive - Please allow time for all images to load!!! **-**



PROBLEM

Early in World War II, German U-boats were sinking alarming numbers of Allied freighters & oil tankers along the eastern seaboard of the United States, with a peak of around 80 ships being sunk per month. This was clearly a National emergency & we needed a technological miracle. Since noisy patrol aircraft could not “sneak up” on these enemy submarines in order to attack them successfully, a stand-off, glider-type weapon was proposed. Ultimately, the **BAT** air-to-surface missile (ASM-N-2: Special Weapons Ordnance Device - SWOD Mk 9) was the first fully automatic guided-missile to be used operationally by any of the combatants during WWII (first combat drop: April 23, 1945; first combat success: April 28, 1945) and was active in the arsenal of the United States Navy from 1945 through 1953. During the latter parts of WWII, there were many wire-, radio-, and television-guided bombs, either glider-type or self-propelled, that were used by the Germans and Americans (e.g., Henschel Hs-293, GB-4), however, the **BAT** was the very first, fully-automatic, weapon system, the archetype of what we now term "fire and forget" weaponry. Once launched, the **BAT** went solo, guided to its target by an early S-band radar unit (see below), developed by the Bell Telephone Laboratories.

BIRDS OF A FEATHER

A family of Secret Weapons was designed for the US Navy by Hugh Dryden (who won the Presidential Certificate of Merit for his work on the Project) and a very creative aerodynamicist named Hunter Boyd.

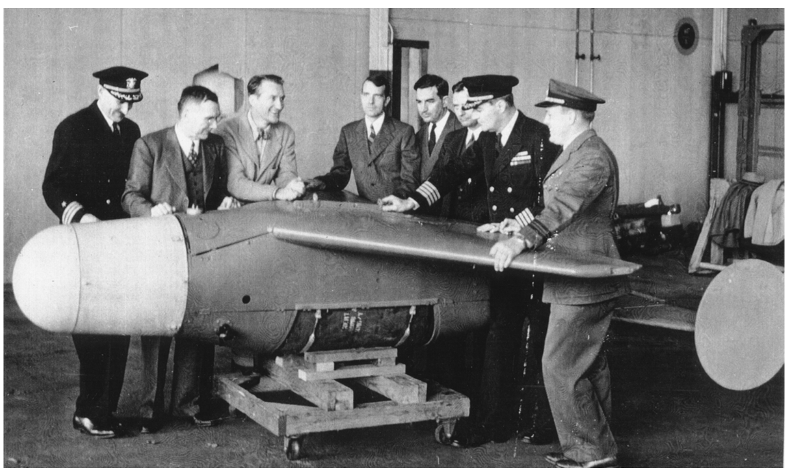
This family of gliders shared a similar layout/planform and were constructed primarily of plywood (in many cases by the Wurlitzer Organ Co./ Vidal Research Co.) & employed elevons attached to

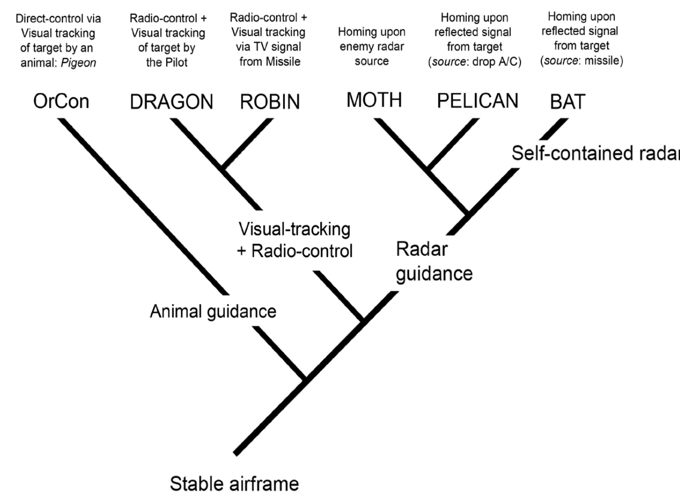
swept-back wings. Several different guidance technologies were evaluated for use in these gliders: radio-control, television, & radar. It should be remembered that in 1941, these “Buck Rodgers” technologies were still very much in their own developmental infancy.

It should also be noted that the BAT project ranked with the Manhattan project (atom bomb) and the proximity fuse as being one of the very few entirely new weapons in WWII.

DEVELOPMENT TEAM (L>R)

RC Newhouse (Bell), HK Skramstead (NBS)
O. McCrackin (BuAer), DP Tucker (BuOrd)
LP Tabor (BuOrd), HL Dryden (NBS)
H. Boyd (NBS), R Lamm (MIT)





RUMOR ABATEMENT

Contrary to several popular articles, none of these devices had a TRUE tail elevator - rather these gliders were equipped with a small trim-tab to maintain missile attitude that was in turn controlled by various types of autopilot found in the different BAT mods (primarily mod-0). All directional control (climb, dive, bank) was performed by the elevons on the main wing. The various projections from the airframe have frequently been misconstrued as air-driven generators, but they were in fact either venturi tubes that drove the gyroscopes or were spinner-type/bomb fuses that spun off, thereby arming the bomb in flight.

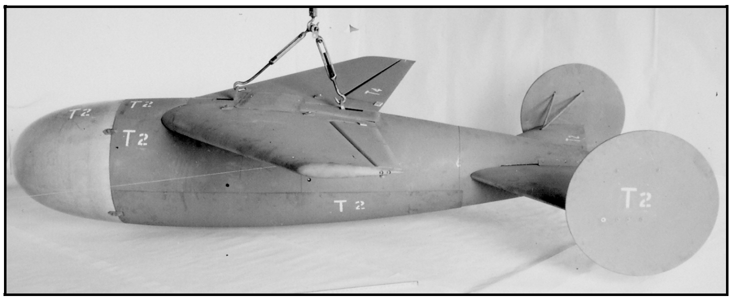
A variety of schemes were tossed around in which only two BATs would be carried beneath the wings of an aircraft (PBJ, PV-1, PV-2, PB-1, PB4Y-1, PB4Y-2b, PBM, PBY) but this load of 2 BATs was primarily dictated by safety/combat-range issues. Other combinations of PELICAN and BAT missiles were investigated wherein a PBJ could be outfitted with 2 BATS in the bomb-bay and two PELICANS beneath the wings. This huge load would obviously make long-range patrol acivity impossible, but consider the impact of a short-range sortie wherein a single a/c could drop four devices against a convoy. Ex: PV-1 at right carries three Mk 16 targets

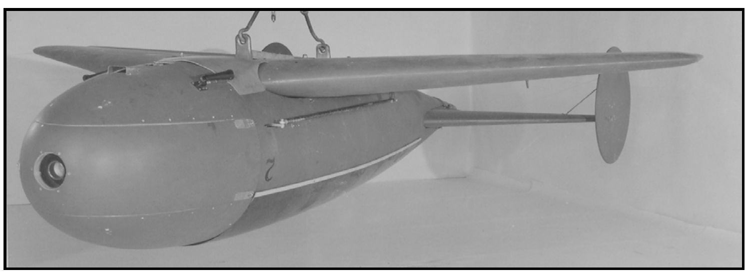
DEVICE	Wing span	Bomb Mark	SWOD	Comments	Air stabilizer
Dryden/Dragon	12'0"			Radio	14:0

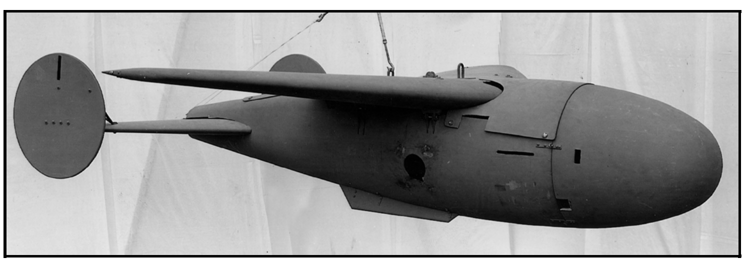
WHAT'S IN A NAME - DEVICE DESIGNATIONS

How does one name secret weapons? Official Navy doctrine

Robin	12'0"			Televison	14:0
Falcon (Rocket/Air to ground)	8'5"			RHB	12:0
Mk16 AA target (Vulture?)	8'5"			Radio	12:0
Moth	8'5"			Enemy-RHB	12:0
Moth (Big)	12'0"			Enemy-RHB	14:0
Pelican Mk 1	8'5"	55:0	Mk 7.0	RHB	12:0
Pelican Mk 2	8'5"	55:1	Mk 7.1	RHB	12:0
Pelican Mk 3	10'2"	56:0	Mk 8.0	RHB	13:0
Pelican (Big)	12'0"	56:1		RHB	14:0
Poor Man's Bat	10'2"			SRB	13:0
BAT-0 (ASM-N-2)	10'2"	57:0	Mk 9.0	SRB	13:0
BAT-1 (ASM-N-2A)	10'2"	57:1	Mk 9.1	SRB	13:0
Bat (Big)	12'0"	69:0	Mk 10.0	SRB	14:0
Kingfisher A	10'2"		Mk 11.0		(?) 14:0
NOLC Corvus	10'2"				13:0







concerning missile-nomenclature dictated that “air-to-surface missiles are to be given names that refer to birds of prey”. BATs, PELICANs, ROBINs, MOTHs, and DRAGONs are **not** ‘birds of prey’ *per se* – I am not entirely sure how the Military missed this subtle zoological nomenclatural point.

There were three basic airframes (air stabilizers 12:0, 13:0, 14:0) that varied primarily in size (8'5" > 12'0" wing span) and capacity (325# depth charges > 2000# GP bombs). Several of these designs were terminated early in their development, whereas others were dropped by the USN but picked up by the Army Air Corps for further development (e.g., ROBIN, MOTH).

Abbreviations found in adjacent table:
RHB - Radar-Homing-Bomb
SRB - Send-Receive-Bomb
'BIG'- System installation in one of the 12'0" gliders
NOLC - Naval Ordinance Lab - Corona

DRAGON

(**Radio-control**: Air Stabilizer 14:0) Wingspan: 12’0”, 2000 lb. bomb. This device is sometimes referred to as the Dryden Bomb. It was a large radio-controlled glider that was to carry a 2000 lb. bomb against ships. Very few were tested & the project was terminated because if the pilot and his aircraft were to accurately guide their missile onto the target, both were subjected to anti-aircraft fire

ROBIN

(**Television-guidance**: Air Stabilizer 14:0), Wingspan: 10’2”, 1000 lb. bomb. During February 1942, Hugh Dryden suggested using television (RCA Iconoscope) as a remote guidance-aide for this glide-bomb. These early cameras were VERY heavy & VERY expensive. The ROBIN project was terminated by the US Navy early-on as there were developmental issues with television camera resolution & the strength/range of the transmitted signal. The Army Air Corps developed a similar project in parallel.

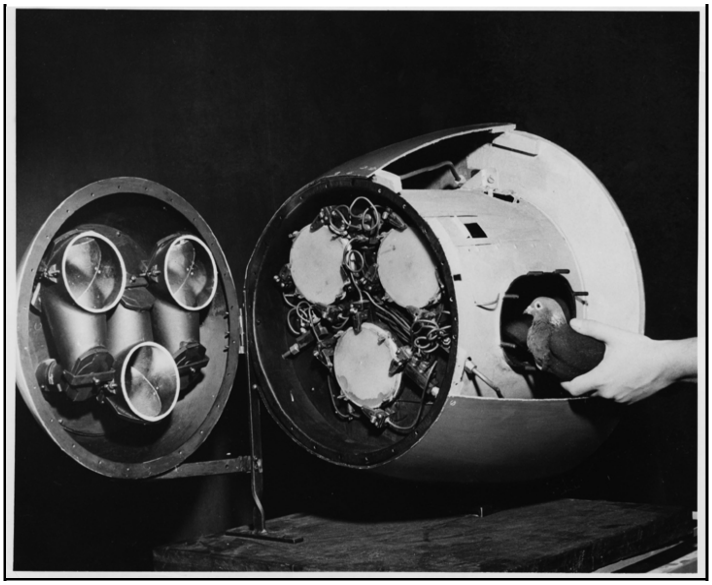
PELICAN

(**Passive Radar- Homing Bomb**: Air Stabilizer 12:0); Wingspan: 8'5", 325 lb depth charge. Operationally, radar signals would be projected onto the target by the launch-aircraft. The PELICAN with its passive radar system would ‘home-in’ on the reflected radar signal. The device first flew March of 1942. However, while guidance problems were being solved, the U-boat menace was being effectively emasculated by the USN and *ULTRA* cryptanalysis. The Navy Brass became fixated on the far *'sexier'* device - BAT - and dumped the PELICAN concept with very little fanfare. PELICAN returned to ‘experimental status’ & terminated by the Navy in Sept. 1944.

PIGEONS IN A PELICAN

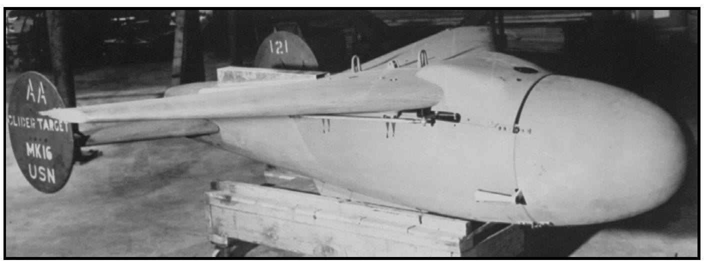
(**Organic control**); Wingspan: 8'5", 325 lb depth charge. The PELICAN-ORCON Project attempted to solve early problems with television & radar - both of which were easily defeated by electronic jamming devices. However, Burrus Skinner convinced the US Navy that birds had great potential as a jam-proof missile-guidance system.

Pigeons were trained to peck at an image of a target projected by a lens onto a screen in the missile's nosecone – these signals then corrected missile's flight-path. Pigeons produced excellent results & were reliable under stressful conditions including extremes in cold, vibration, acceleration, pressure, & noise.



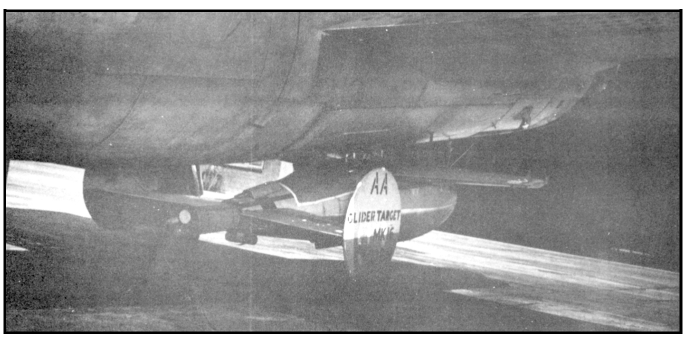
Even though this organic-control system worked extremely well, the Navy would not provide Skinner with sufficient technical data (PELICAN was still ‘TOP SECRET’), and Skinner had an almost impossible task ‘guess-timating’ what electronic inputs/voltages were required to control the gyroscopes & servomechanisms in the PELICAN gyroscopes.

Due to no fault of Skinner’s (nor of his pigeons), the Navy cancelled the program early in 1945.



VULTURE - MK 16 GUNNERY TARGET

(Air Stabilizer 12:0)—Upon cancellation of the PELICAN Project, the Navy was left with a lot of spare PELICAN airframes. Several hundred were converted to anti-aircraft targets in late 1944 and were dropped from patrol bombers as they orbited above the fleet (i.e., PB-1's certainly, others?). The high-angle dive of these sand-filled targets provided an excellent simulation of Kamikaze attacks and an excellent opportunity for Fleet gunners to practice their skills before shipping out to the PTO.

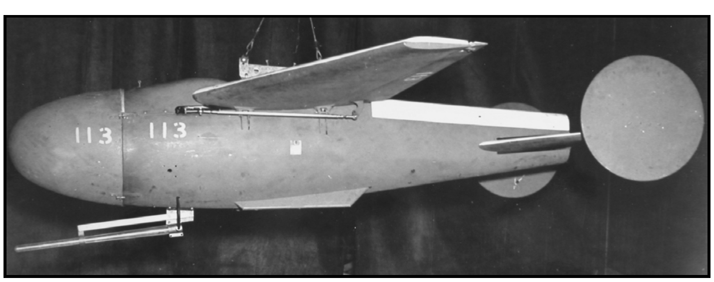


FALCON(?)

This device is clearly a rocket-propelled Mk 16 target glider body suspended beneath a Brewster SB2A a/c. The original photograph was labelled as 'FALCON missile'. However, is this device really a test-bed for the FALCON air-to-ground missile or is it the rarely mentioned rocket-propelled version of the Mk 16 target glider mentioned above?

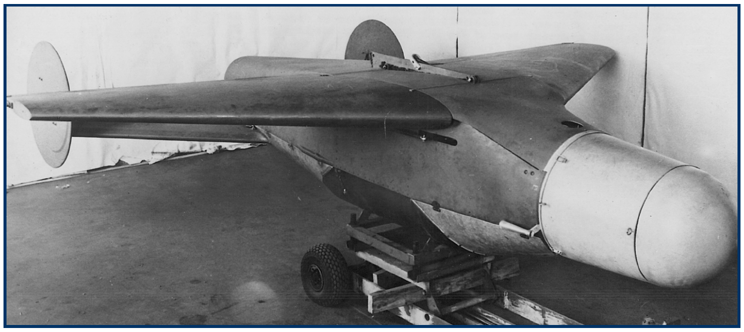
MOTH

(Anti-RADAR-Homing-Bomb: Air Stabilizer 12:0) Wingspan: 10'2", 650 lb bomb. Upon cancellation of the PELICAN, the Navy was left with hundreds of PELICAN airframes. Several were converted into VULTURE anti-aircraft targets (*above*) and many of these were subsequently re-outfitted with antennae and radar receivers that could be tuned to enemy radar frequencies. As real moths are attracted to a flame, MOTH missiles would glide down the enemies’ own radar-signal to destroy the radar installations with its’ bomb. The Navy cancelled MOTH, but the Army Air Corps went on to successfully develop its’ own version of the device.



Poor-Mans' BAT (PMB)

(Air Stabilizer 12:0); Wingspan: 8'5", 325 lb depth charge. This design was a very inexpensive and pragmatic modification of the PELICAN radar system with its own radar sender (tube under nose cone) and relied on the accuracy of the initial approach onto the target by the mother-aircraft. This was a terrific idea that would have had PMBs in the Pacific theater in late 1943, at least 1.5 years ahead of BAT. Sadly, the Navy Brass remained fixated on the far *'sexier'* device - BAT - and walked away from the PMB concept.



ASM-N-2 BAT (SWOD Mk 9)

(Send-Receive-Bomb: Air Stabilizer 13:0); Wingspan: 10'2", 1000 lb bomb. The BAT was a simple glide-bomb constructed of steel & plywood (Wurlitzer Mfg.) primarily designed as an anti-shipping weapon (1000 lb. GP bomb) with a gross weight of 1,700 pounds. Like it's namesake, the BAT had its own internal radar with which to paint its' target and it's own radar-receiver to pick up the echoes from it's 'prey'. As such, BAT was the first fully-automatic target-seeking missile used by any of the combatants during WWII – the World's first "smart-bomb".

NOLC-Corvus

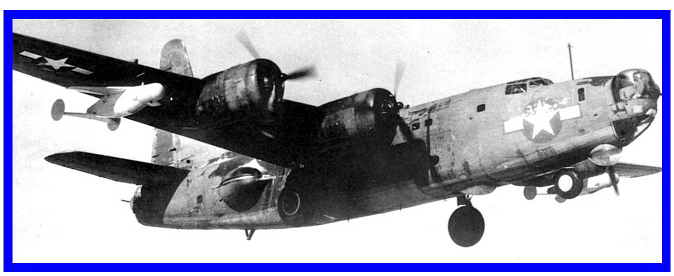
After the war, the National Bureau of Standards Missile Development Division moved to Norco, CA. Those NBS Corona Laboratories became the Naval Ordnance Laboratory, Corona (NOLC) in 1953 and that facility has undergone several face-lifts and redesignations since that time.

NOLC cannibalized SWOD 13.0 ari-stablizers (BAT-1's) and installed a new electronics package / seeker-head into the proven glider airframe and named it the BAT II (aka BATTU/NOLC-*Corvus*).

This device is not to be confused with the TEMCO XASM-N-8 *Corvus* which was the focus of a rather ill-fated program that tried to fulfill a U.S. Navy requirement for a long-range nuclear-armed standoff air-to-surface missile (first tested in July 1959).

AGM-154 (JSOW) - Great great grandson of BAT

Today, one of the great, great grandsons of BAT is the Joint Stand-Off Weapon (JSOW). The AGM-154 is an air-to-surface glider with dimensions that are nearly identical to those of BAT. JSOW is equipped with a 1000 lb. warhead and guided by both Inertial & GPS Systems. This lethal weapon system is exceedingly accurate and has seen considerable action in the last decade.

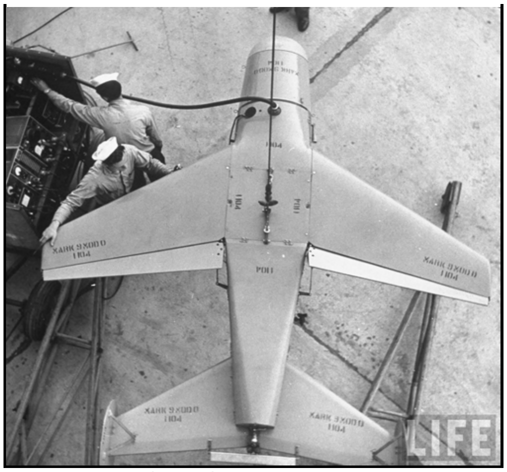


Click on this image of a Consolidated PB4Y-2B *Privateer* to watch film footage of this a/c releasing BAT missiles.

FILM FOOTAGE:

Numerous BAT test flights were conducted after the war at Pt. Mugu and China Lake throughout the late 40's/early 50's. Several mod's to tail fin shape, trim-tab gyros, and avionics resulted and can be seen by the careful observer in these1951 and 1953 excerpts from the Naval Air Warfare Center Weapons Division at China Lake, California.

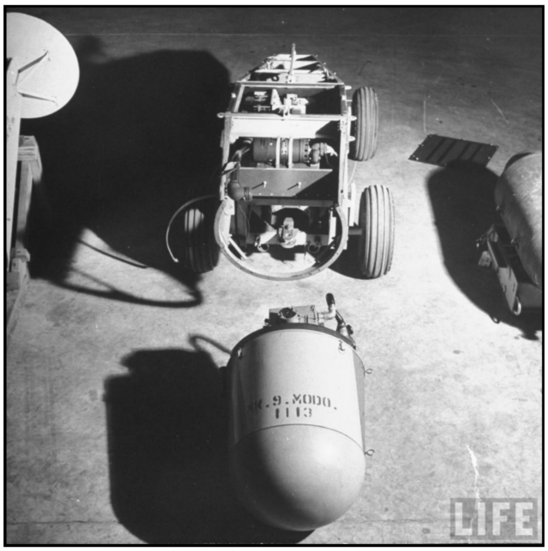
This particular clip was provided by the kind folks at the National Institute of Standards and Technology (NIST). Please visit their terrific Virtual Museum concerning the BAT missile



1946 Photo: Thomas D. McAvoy: LIFE
markings in this photo are unique.

LIFE photo archive now available for the first time through the joint work of LIFE and Google. Add "source:life" to any Google image search and search only the LIFE photo archive.

1946 Photo: Thomas D. McAvoy: LIFE



1946 Photo: Thomas D. McAvoy: LIFE

1946 Photo: Thomas D. McAvoy: LIFE
Interestying detail of Willis bomb-truck, turtle-back, launch braces, and umbilicals during this post-war test.

PB4Y-2B *Privateer* of VPB-123 equipped to launch BAT missiles (USN).
Note: wing-racks and the lowered position of the radome under the A/C

BAT - OPERATIONAL USE

In 1944, the definitive BAT finally emerged and its' first operational use occurred on April 23, 1945 when PB4Y-2B Privateers of Patrol Squadron VPB-109 flew from Palawan in the Phillipines - due to mechanical failures, only one BAT was dropped and that was dropped "blind" and missed. However, on April 28, 1945, VPB-109 sank two small Japanese freighters with BAT missiles during an anti-shipping strike in Balikpapan harbor, Borneo. During this strike, another BAT homed on the strongest RADAR return-signal that it received. Sadly, this target was a large oil tank at the Pandansari oil refinery. Normally, the destruction of the Japanese oil supply would be deemed a good thing, but the Navy had been asked NOT to harm the refinery by the Dutch owners who had hoped the refinery could be spared for their own use after the war.

VPB-109 had been the first squadron to be equipped with the BAT, but was followed soon thereafter by VPB-123 and VPB-124 .The war ended in September 1945, but Navy Squadrons had run out of targets long before that time. Though initial results were less than expected (50% accuracy), the majority of BAT failures can be attributed to insufficient training of flight crews & insufficient technical support & repair facilities in the field, and not to the device itself. Post-war testing demonstrated that this device was very accurate

Fantastic photograph contributed by Roy Balke

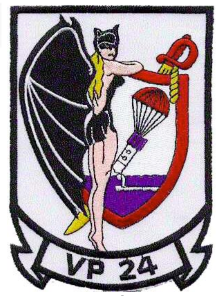
After WWII and without and immediate enemy, post-war *Privateer* crews had to maintain their proficiency by attacking icebergs in the North Atlantic with Bats. In 1953, an upgraded version of the BAT made it's appearance, but was removed from naval inventory soon thereafter. The BAT project produced nearly 3500 weapons, innumerable government patents, & chewed up 8 million man-hours of research effort becoming the Worlds' first fully-automatic target-seeking smart-bomb. The BAT project cost $700 million (in 2004 dollars) and was exceeded only by the Manhattan Project.

SQUADRON SERVICE

The BAT missile system equipped several squadrons and many of these incorporated bats into their unit insignia.
VPB-109, VPB-123, and VPB-124
VP-104 > VPB-104 > VP-104 > VP-HL-4 > VP-24 > VA-HM-13 > VP-24
VP-HL-13 > VP-25


VP-HL-4
(R. Ferrin)

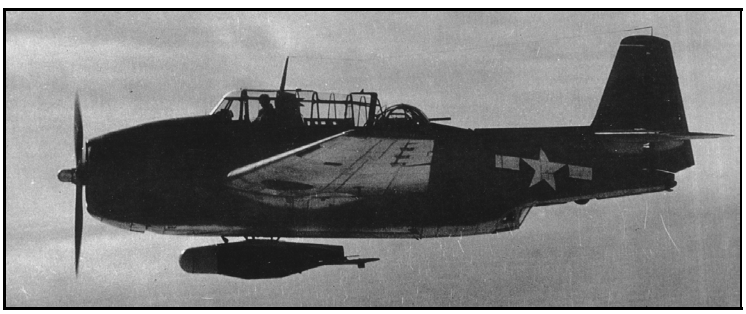

VP-HL-13



VP-24

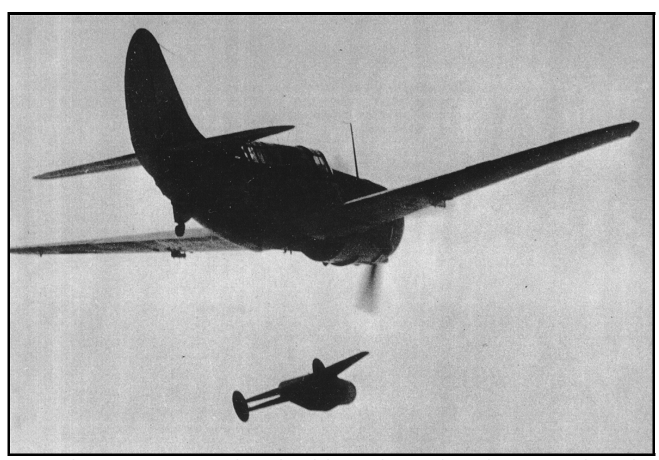

VP-25

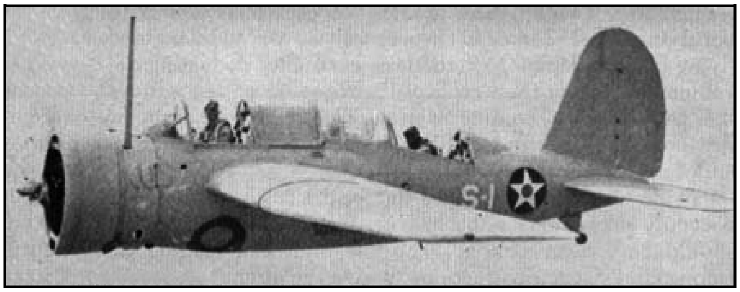
AIRCRAFT THAT CARRIED THE BAT MISSILE


General Motors TBM *Avenger*
BAT missile with fold-down fins. Several of these were used during the early phases of the PELICAN/BAT testing program (US National Archives)


Brewster SB2A *Buccaneer*
Several of these were literally worn out during the early phases of the PELICAN/BAT testing being used as drop aircraft or as photo-chase aircraft


Curtiss SB2C *Helldiver*
(US National Archives)


Several SB2C's were used as drop/photo-chase a/c and even run through catapault tests to access their suitability for BAT use aboard aircraft-carriers.

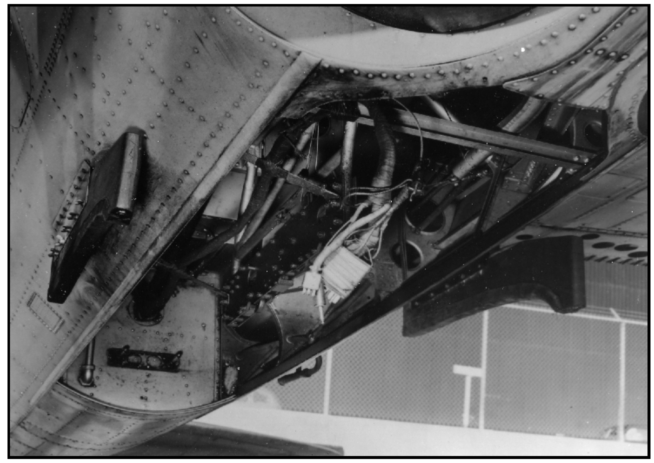


Brewster SBN
Used in early tests of PELICAN

Additional A/C were used in the early test-phases of this program, but not pictured here.
Beech Model 18, Northrop XBT-1, Northrop XBT-2

North American PBJ *Mitchell*
Several of these were utilized in the test phases of the entire family of devices

Grumman F7F *Tigercat*
These a/c were slated for testing/installation but it's doubtful this happened



At least one SBN was used in early tests of PELICAN
Note cradle and umbilicals

Martin JM-1 *Marauder*

Lockheed PV-1 *Ventura*
VP-152 and VP-153 were initially trained to use PELICAN/BAT
but both Sqd.s were re-tasked as ground-attack aircraft

Vought F4U *Corsair*
BAT slung under Vought F4U*Corsair* (Brodie Collection NARA)
Several F4U's were used as drop aircraft or as photo-chase aircraft

Boeing PB-1 (B-17E)
Two Mk 16 targets and Radar are suspended below the bomb-bay

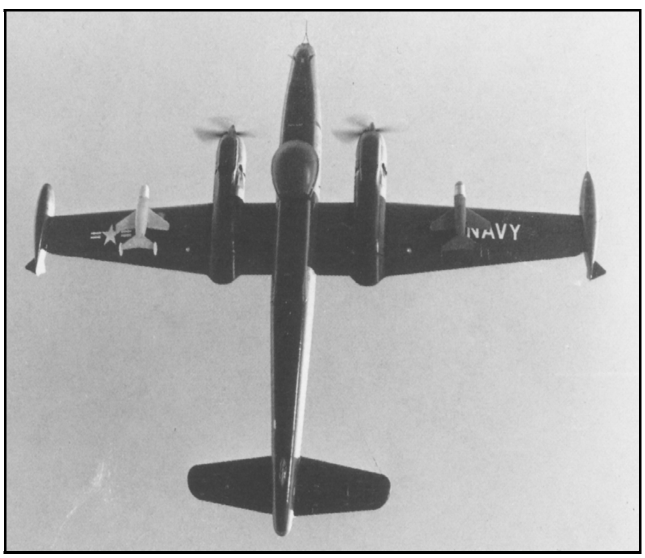
Douglas B-23 *Dragon*
At least one of these a/c was utilized in tests of the early PELICAN airframe

Martin PBM-3 *Mariner*
Several were modified with radar and hardpoints for
BAT deployment but never made it out of the test phase

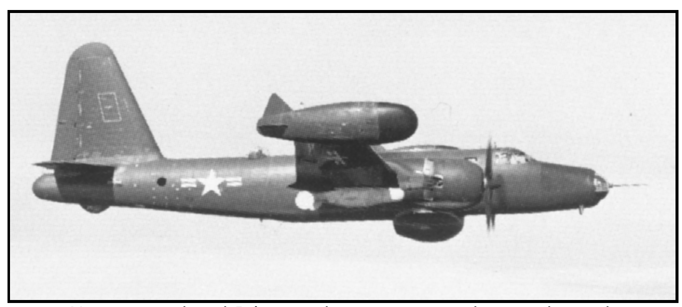
Consolidated PBY *Catalina*
Several were modified with radar and hardpoints for
BAT deploymeent but never made it out of the test phase

Consolidated PB4Y-1
A small handful of -1's were utilized as test-beds - note wing hard-point

Consolidated PB4Y-2B *Privateer*
The *Privateer* was an extensively modified B-24 *Liberator* and
was the first aircraft to carry the BAT in squadron service



Lockheed P2V *Neptune*
The BAT's in this post-war photo are painted differently.
The starboard device is a BAT-0, and the port BAT may be a Mod-1



Neptunes replaced *Privateers* in post-war squadron service and
the BAT finished it's developement beneath these new haulers

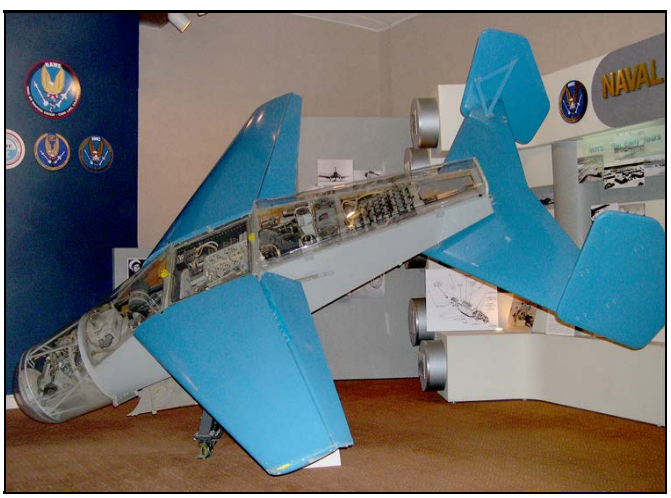
There is always some joker willing to pose great photographs like this one. Point Mugu's BAT-1 has been hung beneath the port wing of a Grumman A-6 *Intruder* operated by VAW-112(?)

At least seven airframes exist in museum collections

BAT-0 at the [Admiral Nimitz State Historic Site]
(Hull #3304:via R. Koone) This BAT could really use a face-lift!

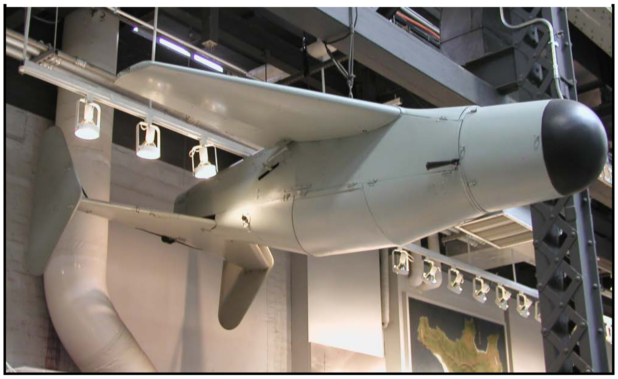
BAT-1 at the [Planes of Fame Museum]
(Hull #2780) (SCP)

BAT-1 at [NAS Point Mugu]
(Hull #3156) (Brian Lockett photo)



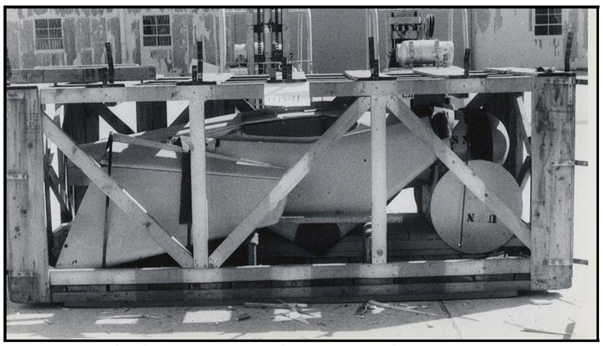
BAT-1 at [NAWCWD China Lake]
(Hull #3049) (SCP) The only "intact" (albeit see-through) bat known to exist.

BAT-1 at the [National Institute of Standards and Technology]
(Hull #3222) (SCP)



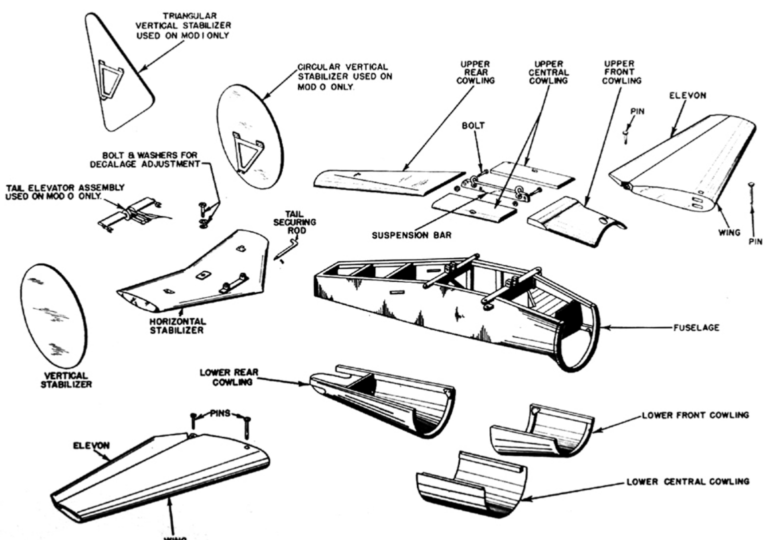
BAT-1 at the **[USN Museum at the Naval Yard, DC]()**
(Hull #unknown) (SCP)

BAT-0 at the **[NASM Udvar-Hazy Center]()**
(Hull #3047/818?) The National Bureau of Standards donated this particular Bat to the Smithsonian June, 1950

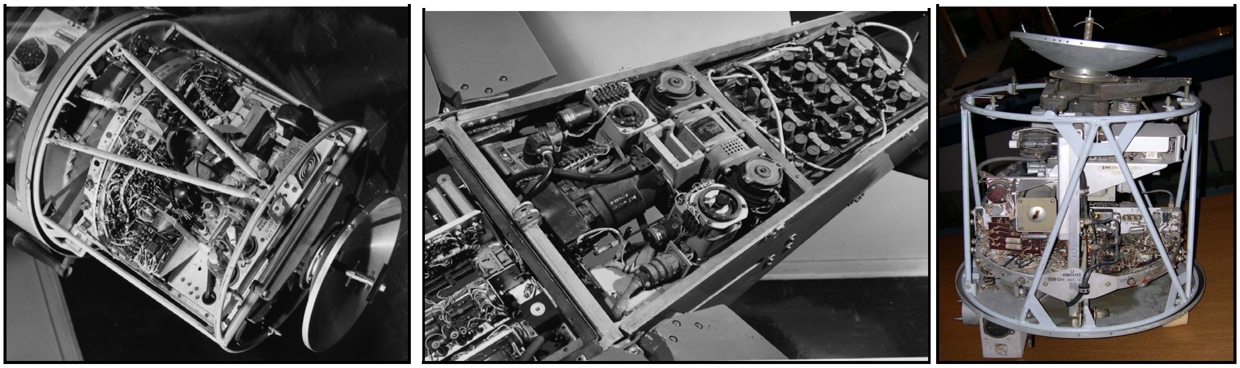


BAT-0 in deep storage at the **[NASM Udvar-Hazy Center]()**
Still in Crate, but there are some electronics on board
(Hull #1093/986?) via: Michael Neufeld

BAT-1 in deep storage at the **[NASM Udvar-Hazy Center]()**
(Hull #2931) via: Michael Neufeld



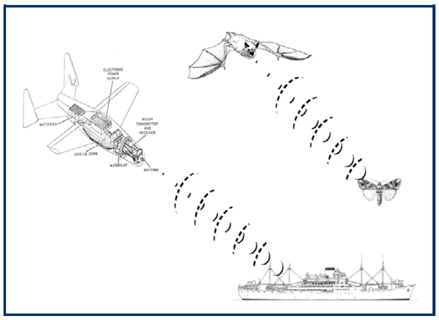
(L>R) Exploded diagram of BAT-0 with BAT-1 tail fins in corner of diagram. Coffin-like battery compartment of the POF BAT-1. The Author personally inspected the craftmanship of this particular hull #2780. Nothing really clever - basic woodworking and hardware fittings but built like a tank. All laminated surfaces were still in terrific shape; all internal components were missing



(L>R) The China Lake BAT-1 has transparent nosecone, fuselage, and battery box covers (see photo below) so that visitors can see the 'guts' of this device. The China Lake BAT is unique in that it is complete except for it's payload. This example is highly polished and carefully painted; any crudeness of the original wood/plywood airframe has been neatly glossed-over. All other BAT's that are known to this Author are merely empty hulls. Spare BAT radar unit at China Lake.

BATS & THE BAT MISSILE—SHARED ENGINEERING PROBLEMS

(animated version of this image - A. Amiotte)



1. Aerodynamic Problems—The Chiroptera employ an inherently unstable, albeit highly maneuverable airframe in order to pursue highly maneuverable targets. Engineers intentionally selected an extremely stable glider design for the BAT in order to eliminate control-problems during a task that did not demand maneuverability (fixed shipping targets). A simple gyroscopic autopilot (Bendix Aviation Corp) contributed to a smooth stabilized flight that could be corrected onto the target by input from the radar in the nosecone of the glider.

2. Send-Receive Problems—The RADAR system in the BAT was based on a device called the 'cavity-magnetron' – an American invention, perfected by the British, & now found in every household microwave oven. The device emitted S-Band (92 mm) pulsed RADAR signals through a parabolic reflector that alternately collected the return-signal for processing by a super-heterodyne receiver. It was easier to use one antenna for both transmit & receive instead of separate antennas but this means that the device could not transmit & receive at the same time. The problem is that the receiver is designed to listen for a faint echo, while the transmitter is designed to send out a powerful pulse. If the receiver were directly linked to the transmitter when a pulse is sent out, the receiver would be overloaded & destroyed. The solution to this problem is to include a circuit element that protects the receiver, effectively becoming an open connection while the transmit pulse was being sent, & then closing again immediately afterward so that the receiver could pick up the echo. Contractions of the muscles in the middle-ear of real echolocating bats are synchronized with the production of echolocation sounds which causes a transient loss in hearing sensitivity (self-deafening) to solve the same problem.

3. Proximity Feed-back Problems—Chiroptera and BAT faced the same problem of increasing reflected signal-strength as either neared their target. Real bats compensate for changes in signal-strength by changing the hearing threshold via precise control over the tympanic reflex or via modulation of emitted signal strength. Sadly, the creation of a receiver with sufficient dynamic range to accommodate for increasing signal strength as the missile approached the target posed a tremendous stumbling block for the state-of-the-art 1940's vacuum-tube electronics.

4. Azimuth, Range, & Elevation Problems—Differences in arrival time and intensity of an echo at a bat's ears provide azimuth and elevation, while target-distance is determined from the time delay between send/receive signals. Chiroptera also employ a wide range of call structures, variations in call amplitude, Doppler-correction, and changes in head position to adjust for target location, size, and activity - BAT and its' vacuum tubes were limited to a fixed frequency, non-steer-able antennae, and was subsequently easily defeated by enemy RADAR-jamming strategies, or by complicated target scenarios consisting of numerous targets of different sizes.

ACKNOWLEDGEMENTS

Curatorial & library staff at the following are gratefully acknowledged for their assistance & their sense of good humor: NMAH, NASM-DC, NASM-UHF, NIST, NARA, NHC-DC, USN Dept. Library, NAS China Lake, China Lake Photo archives, Goleta Air and Space Musuem, NAS Pt. Mugu, NAS Patuxent River, SDAM, UW-NHC, Nimitz Museum, & the History Channel.

Wishful thinking: PELICANS in the PTO in 1943!

NOTE: This is very much a work in progress and is a teaser for book project that is nearing completion. The material herein is a but small fraction of those archival materials that exist in my collection. Nevertheless, further information is requested from Aircrews and personnel who have had experience with these systems. Photographic contributions and stories are appreciated!!

Return to Navigation Bar *Return to Batheads Homepage*