The OV-10 Bronco

Designed for Counterinsurgency and the Vietnam War

The OV-10 Bronco Association

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Introduction

It was a tale like many others from the Vietnam War. A Marine Corps reconnaissance team found itself in contact with an overwhelming enemy force soon after being inserted by helicopter. There was nothing for them to do but maneuver to a clearing large enough to use as a helicopter landing zone and resist the enemy force while waiting for the arrival of a helicopter for extraction. The situation was desperate and would have been fatal for the entire team had it not been for a Marine Corps OV-10A Bronco overhead. The reconnaissance unit was in constant radio contact with the Bronco crew who were aware of the recon team's location and the location of the opposing enemy force. The recon team could hear the enemy as they approached through the brush and the only thing that kept the enemy from overrunning them was the employment of M60 machine guns installed on the OV-10. Each time the Marines on the ground heard the enemy approach, the OV-10 would make a firing pass between the recon team and the attacking enemy force. Using two guns at a time to conserve ammunition, the Bronco crew made multiple strafing passes until the extraction helicopter and supporting armed helicopters arrived.[1]

At this point the OV-10 crew, pilot and aerial observer, could direct armed helicopter runs with guns and rockets on the enemy while coordinating other assets. If the situation required, artillery, naval gunfire, and support from jet aircraft would be directed as well as coordinating medivac helicopter operations.

This was the way the Marine Corps used its OV-10s. The Air Force, with a different mission focus, used them primarily in a forward air control or FAC role across Southeast Asia. They also used the OV-10 in support of search and rescue or SAR missions to recover downed aircrews. The Navy found a different way to use the Bronco and had established an OV-10 squadron of its own in the Mekong Delta to support riverine operations using the Bronco as a light attack aircraft.

The OV-10 was a product of and for the Vietnam War. Of the 271 OV-10As delivered to the United States military, all were delivered before 1970, five years before the war ended. The concept for the airplane began in the minds of two Marine Corps officers before the war in Vietnam began but they had counterinsurgency in Indochina as one of the potential conflicts identified where the airplane would be of value. After initial employment in Southeast Asia, the Bronco underwent modifications and enhancements that were a response to particular needs defined by wartime experience.

This paper, prepared for and presented at the 2015 Violent Skies Symposium, will address the development of the OV-10A Bronco and its particular association with the prosecution of the Vietnam War.

[1] 1/Lt Zachery T. Johnson, USMC, addressing 3rd Platoon, C Company, 72d OCC, Marine Corps Base, Quantico, VA, 1971 per Ashby Shoop 2015

1. The Concept

The idea behind what was to become the North American Aviation Model 300, the OV-10 Bronco, had its origin as a series of conversations between two Marine Corps pilots who were Korean War veterans; Majors W.H. Beckett and K.P. Rice. This sort of conversation inevitably began, "What the Marine Corps really needs…" as have many conversations among Marines since 1775. What was different about these conversations is that they resulted in the Majors drafting a paper entitled, Light, Light Support Aircraft, or L²VMA, VMA being the designation for a Marine attack squadron. The paper was subtitled, *"The Need, Concept of Operation and General Specifications for a Very Light S.T.O.L. Support Aircraft"*.[2] STOL or short takeoff and landing is generally defined as a takeoff clearing a barrier 50 feet high with it requiring no more than 500 feet takeoff roll. Their airplane was designed around an emerging need for air support in a limited war situation. A specification diagram is included here, in Figure 1. Some important characteristics include:

1) Capable of operating with troops off of unimproved fields or roads lined with trees requiring a trailing arm type of landing gear.
2) Capable of STOL operation.
3) Shoulder mounted wing with the crew area unobstructed in a forward location.
4) Capable of supporting helicopter or armored operations.
5) Capable of supporting anti-helicopter and anti-armor operations.
6) Capable of performing armed reconnaissance.
7) Capable of burning any type of fuel, especially that available in a ground unit.
8) Capable of utilizing ground unit ordnance including .30 machine guns and a 106mm recoilless rifle.
9) Capable of reconfiguration, from attack to cargo.
10) Capable of accommodating an observer.
11) Capable of water based operation with floats.

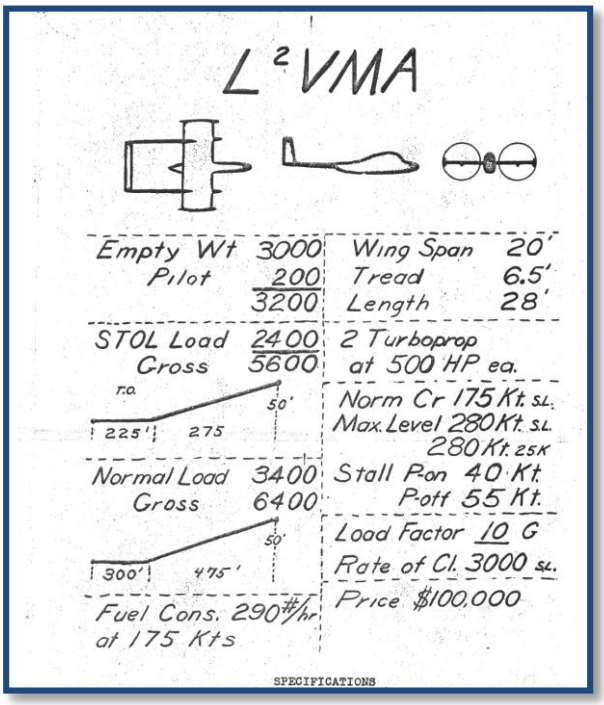


Figure 1: L²VMA Specification, Beckett and Rice, 1960

Their paper emphasized that although the focus of the development of military aircraft at that time (1960) had been on the high end with supersonic and nuclear capability, in a limited war situation, *"…back in the foxholes of Korea, the jungles of Indochina, and the sands of Israel*

[2] Maj W.E. Beckett USMC, Maj K.P. Rice USMC. *Light Light Support Aircraft (L²VMA), The Need, Concept of Operation and General Specification For A Very Light S.T.O.L. Support Aircraft,* Unpublished, OBA Version (Annotated by K.P. Rice) 1960

and Jordon, war proceeds pretty much as usual." They looked at likely operating scenarios for a L²VMA airplane and included what would now be called low observability through the use of non-radar reflecting fiber glass and paint. As can be seen in Figure 1 it was a twin engine twin tail airplane that looked remarkably like an OV-10. The high tail was required to clear the back blast of a centerline mounted recoilless rifle that was their preferred weapon.

The ordnance load envisioned for the L²VMA illustrated in their paper is provided in Figure 2. Included are both aviation-sourced weapons such as bombs and rockets, and infantry-sourced weapons.

the paper) and briefed anyone who would listen, including the commanding general at El Toro, who fell asleep."[3] Briefings were provided for industry representatives as well. They went so far as to begin building a mockup of what the L²VMA would look like out of plaster and fiberglass. The two Majors were attempting to build an airplane outside the acquisition and research and development DOD processes. In the end they surrendered and began working to get the L²VMA program executed inside the system.

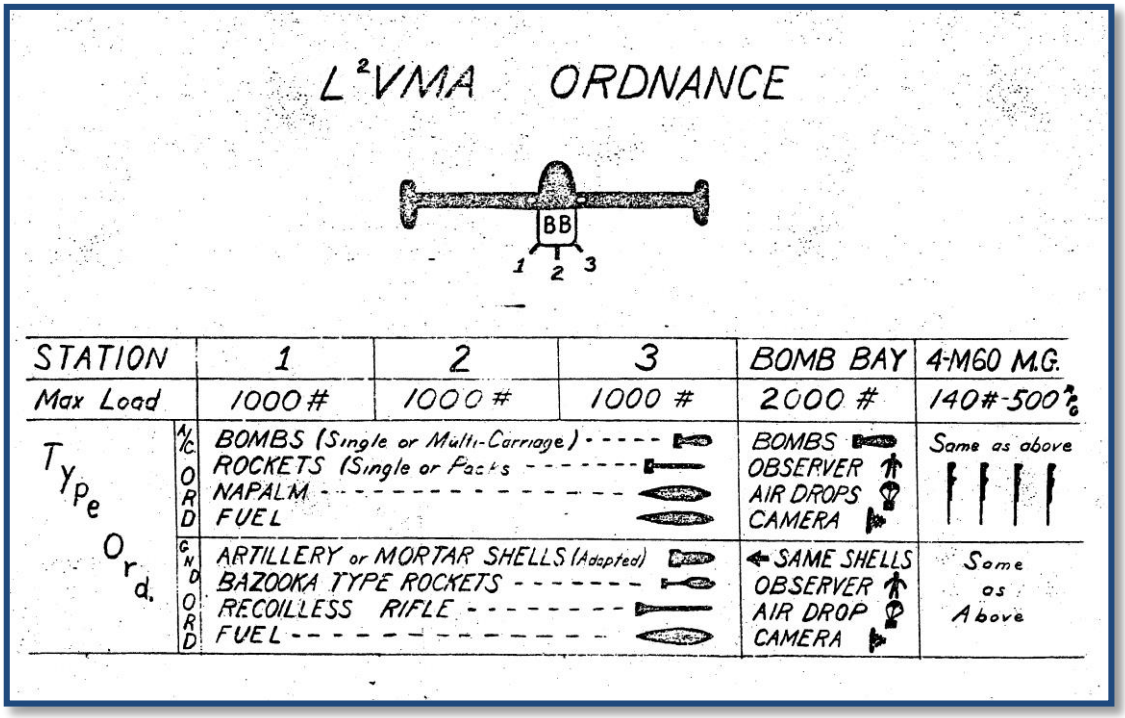


Figure 2: L²VMA Proposed Ordnance, Beckett and Rice, 1960

In pursuit of their concept, Majors Beckett and Rice were willing to brief anyone at any time, As K.P. Rice said. "*This we wrote first (speaking of*

[3] W.H. Beckett, K.P. Rice, M.E. King. *OV-10 Story, Innovation vs the "System"*, unpublished OBA Version (annotated by K.P. Rice), undated

2. The Design Competition

Major Rice approached working in the system with the same enthusiasm as he had trying to work outside the system. He enlisted the help of a friend and former Marine Corps test pilot working in DOD Research and Engineering (DDR&E). Through him and the with the assistance of Col Marion Carl, Major Rice was able to obtain TAD orders to DDR&E where he led the development of the concept for a counterinsurgency or COIN aircraft. This resulted in a letter from Harold Brown, then head of DDR&E, to the Assistant Armed Service Secretaries describing a Light Armed Reconnaissance Aircraft, or LARA. Initially the Marine Corps and Army were interested in developing the airplane with the Army considering a replacement for the OV-1 Mohawk. Later the Air Force expressed an interest in developing a new airplane for the forward air control (FAC) mission. The Navy expressed no interest in a LARA aircraft but agreed to be the procuring and development agency.[4] In the last quarter of 1963, a request for proposal, RFP 0083-64, was prepared by the Navy and issued to twenty-two aircraft manufacturers for a LARA/COIN design.[5] LARA requirements included two turbine-driven propellers, a tandem two seat configuration, the ability to operate from short unimproved fields and aircraft carriers without special equipment, an armament consisting of at least four 500 pound bombs and four internal M60 machine guns. The RFP also included a requirement to convert to other roles with the ability to carry 2000 pounds of cargo, or six paratroops, or stretchers and the ability to operate in an amphibian configuration with floats.[6]

At least ten design proposals came from some of the major aircraft houses of the time with the addition of a couple of surprises. Submitting designs were:

1) Beech
2) Douglas
3) Convair
4) Goodyear
5) Grumman
6) Helio
7) Hiller
8) Lockheed
9) Martin
10) North American

Ryan Aeronautical who had been included in earlier briefs by the Majors and had a reasonable preliminary design decided not to bid. Grumman had proposed a variant of their existing twin engine STOL aircraft built for the Army, the OV-1 Mohawk, modified with a tandem cockpit and it received an early dismissal as did the Helio revamp of their existing STOL transport. All the entries had twin turboprop engines, using either Pratt Whitney T74 or Garrett T76 power plants. The Martin design had engine exhausts exiting at the end of each tail boom that supported an inverted V tail. The Goodyear proposal had a

[4] W.H. Beckett, K.P. Rice, M.E. King. *OV-10 Story, Innovation vs the "System"*, unpublished OBA Version (annotated by K.P. Rice), undated

[5] Steve Ginter, *Convair Model 48 Charger*, Naval Fighters 1997

[6] James Wegg, *General Dynamics Aircraft*, Putnam London 1990

short wing and engines mounted above the wing on pylons.[7]

Some but not all of the L^{2}VMA specifications found their way into LARA/COIN designs. Of the ten proposals, four used the L^{2}VMA model configuration of twin booms supporting a high tail that would accommodate a recoilless rifle on the aircraft centerline. However other L^{2}VMA features were ignored. In the RFP, a short wing was required rather than a wingspan of 20 feet; short enough to operate from tree lined roads. No competitor was offering a 20 foot wingspan so unprepared road use was out of the question. However, rough field operation was still a requirement which added 1000 pounds to the design gross weight. The addition of Air Force FAC requirements added another 1000 pounds of avionics and communication equipment. LARA/COIN designs were almost twice as large and heavy as envisioned in the L^{2}VMA specification and had additional complexity such as instruments for bad weather flying and ejection seats. Major Rice had been warned by a senior Department of the Navy Research and Development official that working within the system was bound to greatly add to the complexity of the result.[8] But at least now through LARA/COIN, L^{2}VMA had a chance to be built.

The winner of the design competition was North American Aviation, Columbus Division who was contracted to build nine prototypes. Convair had built a flight demonstration aircraft called the Charger before the LARA/COIN RFP was issued that seemed to meet all the requirements. Having lost the design competition, Convair was eager to have their entry evaluated. But the sole example was destroyed in a crash caused by a Navy test pilot and Convair was finally eliminated.[9] The North American Model 300, the YOV-10A Bronco was going on to a Tri-Service Evaluation. The multi-service evaluation concept was formed by K.P. Rice and W.H. Beckett when they encouraged the formation of the ASEG, the All Service Evaluation Group. The ASEG had been prepared for LARA flight testing by being exposed to various airplane types and capabilities that included some time spent studying low level flight under the instruction of crop dusters.[10]

[7] Steve Ginter, *Convair Model 48 Charger*, Naval Fighters 1997

[8] W.H. Beckett, K.P. Rice, M.E. King. *OV-10 Story, Innovation vs the "System"*, unpublished OBA Version (annotated by K.P. Rice), undated

[9] W.H. Beckett, K.P. Rice, M.E. King. *OV-10 Story, Innovation vs the "System"*, unpublished OBA Version (annotated by K.P. Rice), undated

[10] ibid.

3. YOV-10A Prototype

The initial Navy contract with North American, referred to as Lot 1, was to design, build, and test nine YOV-10A prototype airplanes. Cost of this portion of the program was approximately $15 million.[11] Seven of these were intended for flight and two would be used for ground testing of the airplane's structural strength; one for static testing and one for fatigue testing. Immediately following the contract award, North American began creating a detailed engineering definition of what was to become the OV-10A.

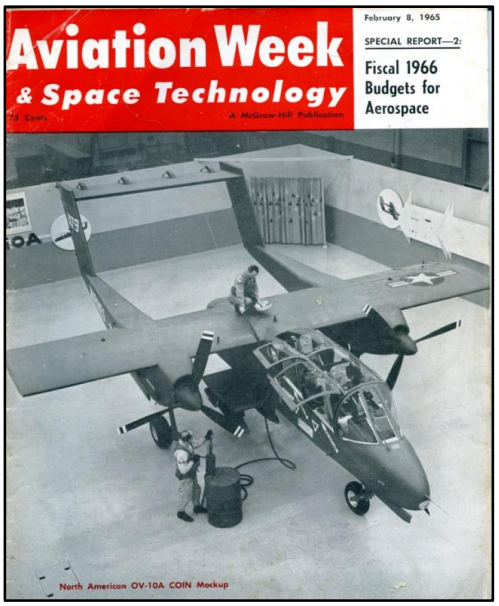


Figure 3: AW&ST Cover, OV-10 Mockup

3.1 The Mockup

First to be built was a full scale mockup that resembled in every way the prototype airplanes. It incorporated the fundamental design features planned for the aircraft. Made of various materials including aluminum, fiberglass, wood, and steel, the mockup was the first physical manifestation of the basic OV-10 design.

Figure 4: OV-10 Mockup Restored, 2001

[11] "OV-10A*", Columbus Division News,* North American Aviation, Inc., Columbus, OH., undated

A mockup on a major program may have several purposes. Some of these are 1) Design Proof of Concept, 2) Support of Detailed Design, 3) Human Factors Evaluation, and 4) Public Relations Support. In the public relations arena, the OV-10 mockup was a star having been selected to grace the cover of Aviation Week & Space Technology the week of February 8, 1965, Figure 3. The accompanying article indicates that this mockup was one of the most detailed ever constructed by North American. By the time the mock up was revealed in early 1965 it had been used along with released engineering for review of the OV-10 design by a Department of Defense board. The board consisting of members from the Army, Navy, Marine Corps, and Air Force approved the design. The AW&ST article notes that overall dimensions of the mock up and the final design had been set with small changes from the original submission.[12] A visual inspection of the mockup reveals features unique to the YOV-10 including a 30 foot wing span and horizontal sponsons. Much of the mockup is constructed as the actual airplane would be in aluminum and fiber glass. Other mockup features are simulated in wood such as floors and line replaceable units like radios and electronics. The instrument panel was also made of wood although the instruments themselves are actual hardware. Differing from airplane construction, the wing spar of the mockup was made of steel rather than aluminum.[13]

The OV-10 mockup was rescued by the OV-10 Bronco Association (OBA), restored as shown in Figure 4, and placed on display at the Fort Worth

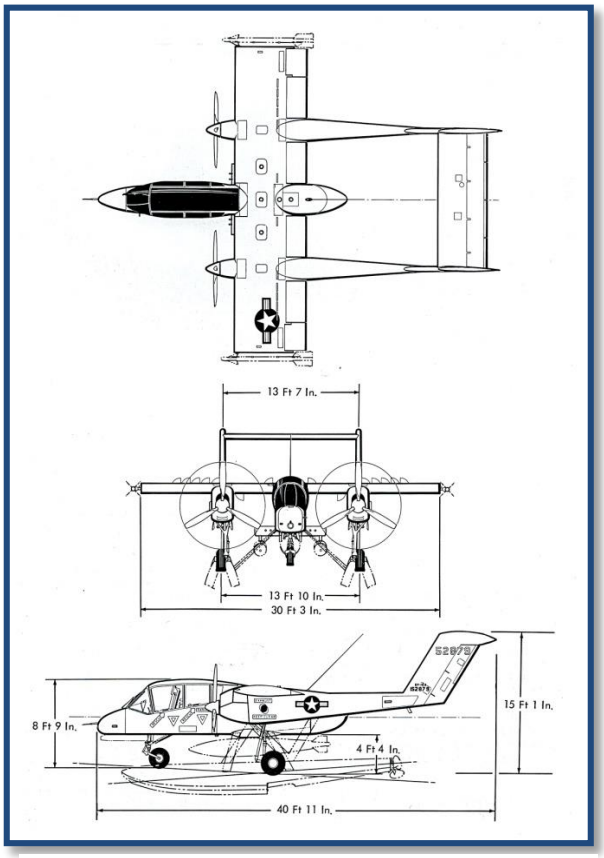


Figure 5: Initial YOV-10A Configuration

Aviation Museum at Meacham International Airport where the OBA collection is located

3.2 YOV-10A Flight Test

The first flight of the YOV-10 occurred on 16 July, 1965 at Columbus, OH by aircraft number 1, two months ahead of the program schedule first flight date. YOV-10 number 1 is shown in Figures 5 and 6. Note the retention of floats leftover from the L^2VMA specification. Numbers 2 through 4 followed in November, December, and January. All the prototypes were built with a 30 foot wing span and with 660 shaft horse power (shp) Garrett T76 engines. Number 5 was later configured with a 34 foot wing having Hoerner wing tips and Number 6 was configured with a

[12] Donald F. Fink, "North American Accelerates COIN Work", *Aviation Week & Space Technology*, February 8, 1965

[13] Charles Burin 2015

40 foot wing. Number 7, the final YOV-10, was equipped with alternate T74 engines.[14]

It should be noted that test status memos included Lt Col K.P. Rice on distribution. He was the government program manager. Flight testing progressed through 50 hours of contractor directed stability and control Category 1 testing[15] and by February 1966 126 hours had been flown.[16]

NPE TESTING: Navy Preliminary Evaluation (NPE) began in March 1966 with airplanes 1, 2, and 3. These consisted of flight qualities, performance, and operational test flights totaling 77 hours. [17] These tests included the well-known rough landing exercise. A washboard undulating runway surface was constructed and airplane number 4 was used to evaluate rough runway takeoffs and landings. Later the same airplane was used to demonstrate ground operations over simulated holes and obstacles.[18] The rough field capability was a specification holdover from L^2VMA that had little operational meaning but added weight and complexity to the operational OV-10. The airplane passed the test but it was a challenge to pilots. Airplane number 4's structure was permanently distorted by rough field testing and it was not flown again after a ferry flight back to the North American Columbus, Ohio plant.[19]

Figure 6: YOV-10A Aircraft #1

[14] "*YOV-10A, OV-10A Program Brief",* North American Rockwell Corporation, Columbus Division, 6 June 1969

[15] Donald F. Fink, "North American Accelerates COIN Work", *Aviation Week & Space Technology*, February 8, 1965

[16] *"Program Summary"* North American Aviation Memo No. 2, 25 February 1966

[17] *"Program Summary"* North American Aviation Memo No. 5, 18 March 1966

[18] *OV-10 Newsletter*, North American Aviation Inc., Columbus Division, November 1966

[19] Charles Burin, Conversation with NA Test Pilot Archie Lane 1999

ASEG TESTING: Starting in February 1967 while NPE testing was still being conducted, the All Service Evaluation Group (ASEG) investigated service suitability, operational mission, and tactics[20] Just prior to the start of this phase of testing the OV-10 officially received the name "Bronco". ASEG testing included weapons integration and they developed procedures for parachute operations from the OV-10 later used by the Marine Corps.[21] Their home base was NAS Patuxent River Maryland but they conducted testing at various specialized locations including Eglin Air Force Base in Florida and Marine Corps Air Station New River, North Carolina.

All aircraft were updated to address deficiencies identified in earlier tests. As a result, all the ASEG airplanes were all equipped with 34 foot wings instead of the original 30 foot wing. For the ASEG test program, airplane 4 was replaced by number 7 after it was damaged in rough field testing and number 3 replaced number 5 after it was lost in a crash in NPE testing on 1 February.[22] Aircraft 6 was briefly removed from testing to be displayed at the Paris Air Show. It became the first OV-10 to fly from an aircraft carrier when the USS Saratoga ferried it to the Mediterranean for a deck takeoff on its way to Paris. Number 6 was returned to the ASEG in June following its reassembly after a flight home in a C-141.[23] As a result of ASEG tests configuration of controls, engines, and other systems were evolving and migrating toward the final Lot 2 production configuration.

Category 2 operational testing followed deliveries of YOV-10s number 6 and 7. Early testing had revealed deficiencies in low speed stability and control which resulted adoption of the 40 foot wing on airplane number 6. This wing included a seven foot long 20 percent chord width revised aileron to correct roll authority issues found on the 30 foot wing.[24] A deficiency in single engine performance led to the upgrade of engines to 715 shp for production

Defense Secretary McNamara had said in August of 1965 that there would be no production purchase of OV-10s as he chose to rely on existing F-4 Phantom, A-6 Intruder, and A-7 Corsair II aircraft to fill the need in Vietnam.[25] That position was ultimately reversed and in November 1966 the first option to exercise Lot 2 was made and a total of 185 airplanes ordered for the Air Force and the Marine Corps. Following operational testing, both USMC and USAF together accepted delivery of their first OV-10s on 23 February 1968

Figure 7: YOV-10A Aircraft #4, All That Remains, On Display at the Fort Worth Aviation Museum

[20] *OV-10 Newsletter*, North American Aviation Inc., Columbus Division, November 1966
[21] W.H. Beckett, K.P. Rice, M.E. King. *OV-10 Story, Innovation vs the "System"*, unpublished OBA Version (annotated by K.P. Rice), undated
[22] *OV-10 Newsletter*, North American Aviation Inc., Columbus Division, 28 February 1967
[23] *OV-10 Newsletter*, North American Aviation Inc., Columbus Division, 28 April 1967
[24] *OV-10 Newsletter*, North American Aviation Inc., Columbus Division, December 1966
[25] "No Large OV-10A Buy For Vietnam" *Aviation Week and Space Technology*, August 16, 1965

4. The OV-10A Bronco

The OV-10A Bronco Airplane

The airplane characteristics and dimensions are examined below.[26]

Figure 8: OV-10A Bronco Revealed

OV-10 COMPARISON TO THE YOV-10 PROTOTYPES: The production Bronco differed from the YOV-10 in several ways. The production airplane was delivered with a wingspan of 40 feet, a modification first made on YOV-10 number 6. The wing was a completely new design incorporating five fuel cells for a total of 252 gallons compared to three fuel cells and 210 gallon capacity. Sponsons were angled downward rather than being horizontal providing more propeller arc clearance for sponson mounted forward firing weapons. The airframe was less than twenty pounds heavier than the YOV-10 after modifications were made following structural improvements identified in testing.[27] Engines were upgraded T76s producing 715 shp each versus 660 shp for the YOV-10. Otherwise the systems and installations further described were very similar to the first seven Bronco prototypes.

[26] If not credited material in support of this section is taken from: *Columbus NAA Division Service News, Vol. XVI No. 7* Feature Issue, "OV-10A "Bronco"", August 1967 *Columbus Division Service News*, North American Rockwell Corporation, Vol. XVI, No. 10, Feature Issue, "OV-10A "Bronco" Crash Rescue and Fire Fighting Information", November 1967; *Preliminary NATOPS Flight Manual*, "Navy Model OV-10A Aircraft", NAVAIR 01-60GCB-1, 15 February 1968; *NATOPS Flight Manual*, "Navy Model OV-10A Aircraft", NAVAIR 01-60GCB-1, 15 February 1969 and *Flight Manual USAF Series OV-10A Aircraft*, T.O. 1L-10A-1, 1 September 1968.

[27] " YOV-10A", *OV-10A Program Brief,* unpublished North American Rockwell Corporation, Columbus Division, 6 June 1969

FLIGHT CONTROL SYSTEM: The flight control system is depicted in Figure 9. To adequately address the broad difference in operational airspeed; from 45 to 450 knots[28] slotted flaps, spring tabs, and lateral control spoilers are all integrated into an unboosted redundant mechanical system. At the time of its design in 1965, it was noted that a similar mechanical system had not been seen on a new military airplane since the 1950s.[29] The spoilers are pie segment shaped discs that rotate out of the down moving wing to increase the roll rate over ailerons alone. Observer's flight controls are without trim controls and are removable to increase cargo capacity.

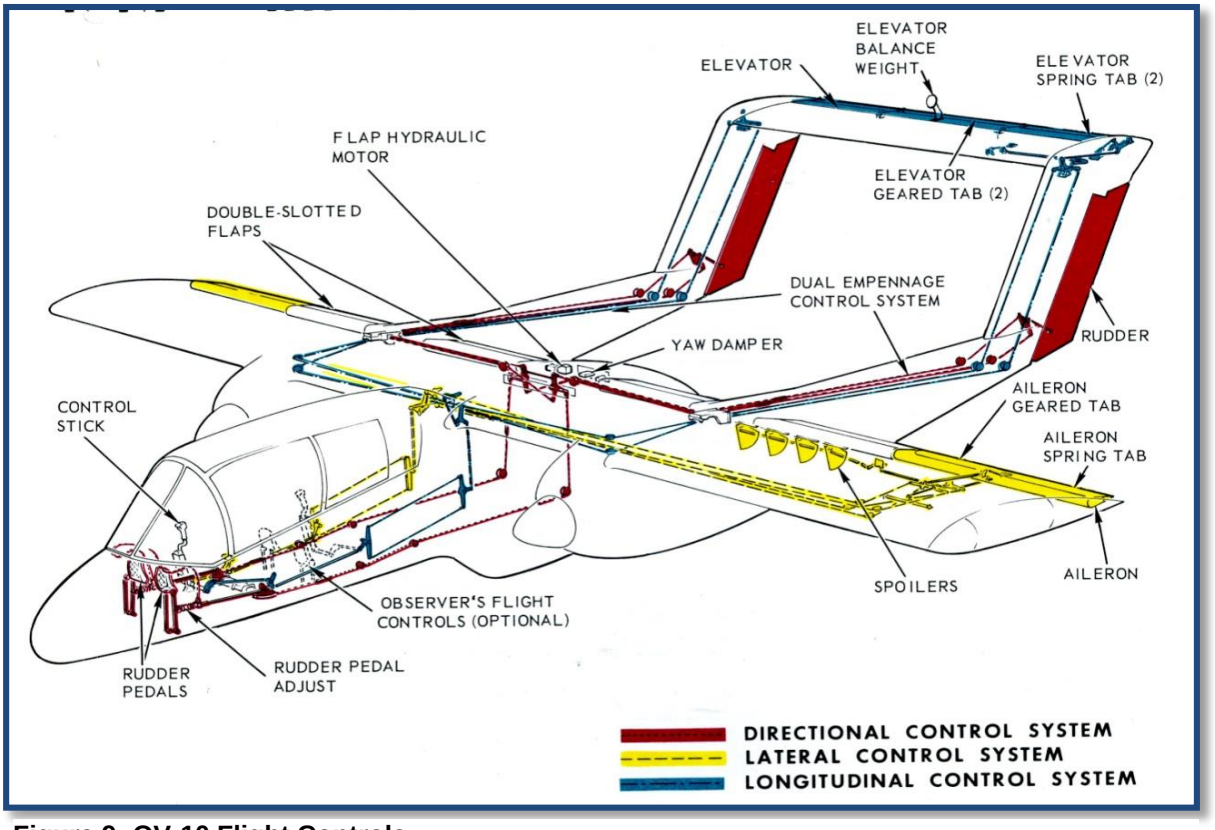


Figure 9: OV-10 Flight Controls

FUEL SYSTEM: In addition to the wing tanks described earlier, provisions are made for an additional 150 gallon external tank mounted on the centerline for the Marine Corps and a 230 gallon external centerline tank for the Air Force. Transfer from the external tank to the wing tanks is accomplished through an electric transfer pump. Otherwise fuel flow to the engines from the wing tanks is by gravity feed.

PROPULSION: The OV-10A propulsion system consists of two Garrett T76 turbo prop engines rated at 715 shaft horsepower mated to three bladed aluminum propellers with an 8 1/3 foot diameter. Engines are geared left and right so that propellers turn inward to reduce adverse torque effects and provide symmetrical airflow

[28] "YOV-10A", *OV-10A Program Brief,* Unpublished North American Rockwell Corporation, Columbus Division, 6 June 1969

[29] Donald F. Fink, "North American Accelerates COIN Work", *Aviation Week & Space Technology*, February 8, 1965

over the wing. Propellers are fully reversible with aircraft weight on the main landing gear.

HYDRAULIC SYSTEM: The hydraulic system is an on-demand system that powers the flaps, landing gear extension and retraction, and nose wheel steering. The pump is located in the aft ceiling of the cargo bay. Pump failure is backed up by electric operation of the flaps and gravity release for landing gear extension.

self-sealing. Flight controls are designed with redundancy.

COCKPIT: The initial cockpit configurations are shown in Figure 10. The cockpits are configured so that the airplane may be flown and landed, and mission radios operated from the backseat but engine start and takeoff may not be initiated from the rear cockpit. The canopy design provides unparalleled visibility in all directions.

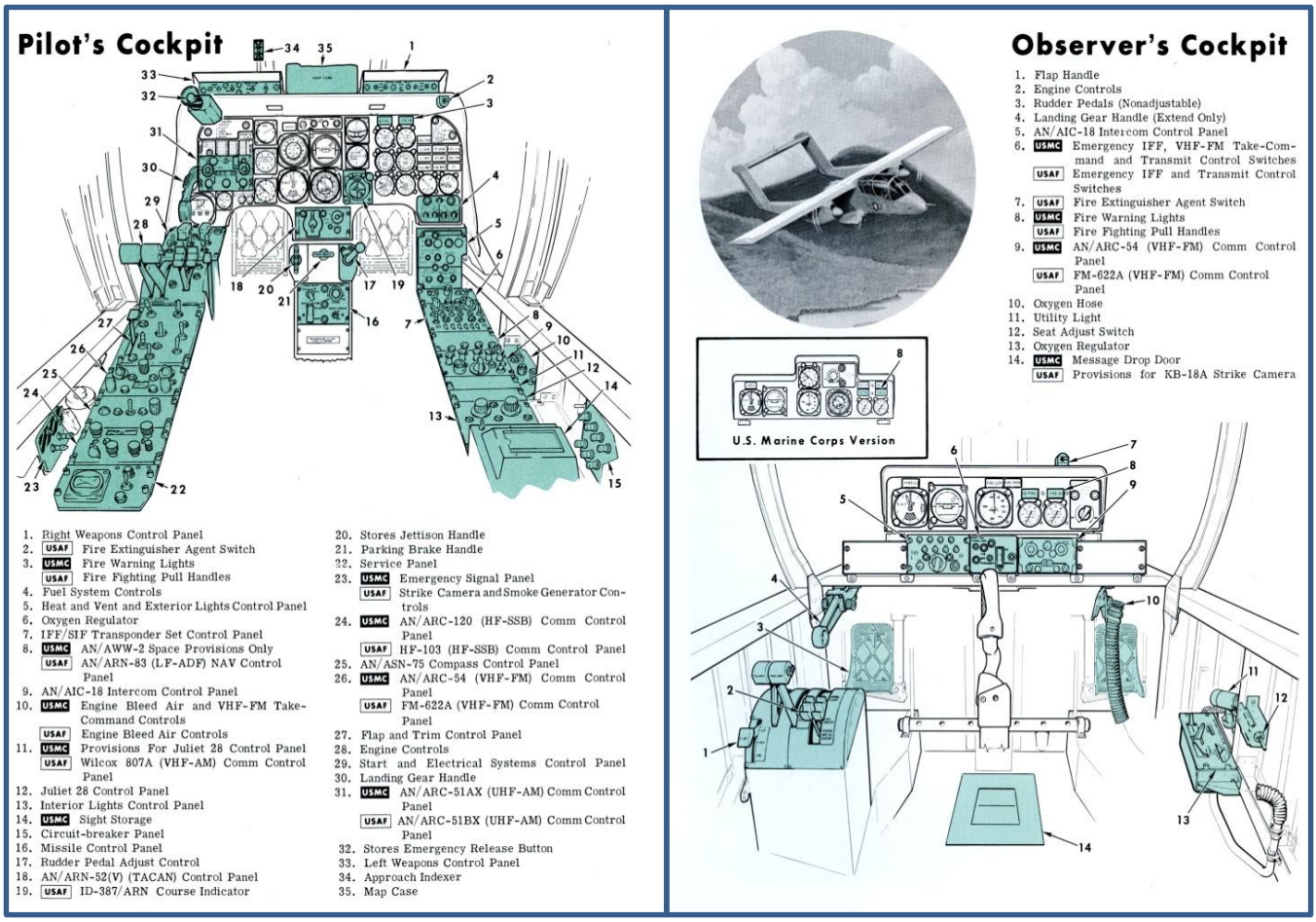
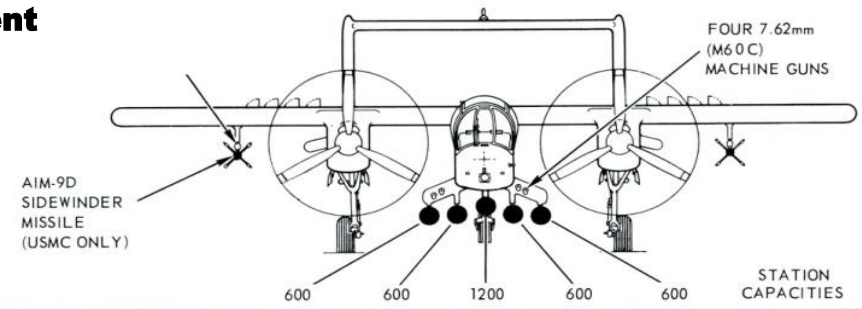


Figure 10: OV-10A Cockpit Arrangement

SURVIVABILITY: Both crew members are provided with LW-3B zero-zero ejection seats. The occupant of the front eat ejects both airplane occupants while the back seat has control of just rear seat ejection. The crew compartment is equipped with armor plating in the floor and fore and aft edges of the cockpit. The fuel tanks are

ARMAMENT: The initial OV-10 armament list is shown in Figure 11. As the Vietnam War continued other weapons were added and some deleted. The armament system is complemented by an illuminated optical sight installed in the front cockpit. The armament list should be compared to the Cessna O-1 Birddog and O-2 Super Skymaster that the OV-10 was

OV-10A Armament



ORDNANCE	STA 5	STA 4	STA 3	STA 2	STA 1	WT.(LBS)
General-purpose, Low Drag (GPLD) Bombs						
MK 81	●	●	●	●	●	260
MK 82	●	●	●	●	●	531
MK 83			●			985
MK 117			●			823
General-purpose (GP) Snakeye Bombs						
MK 81	●	●	●	●	●	295
MK 82	●	●	●	●	●	572
Fire Bombs						
MK 77 Mod 2	●	●	●	●	●	520
MK 77 Mod 3	●	●	●	●	●	520
MK 122 Mod 0 (Fireye)	●	●	●	●	●	225
Rocket Packages						
LAU-3/A	●	●		●	●	416
LAU-10/A	●	●		●	●	533
LAU-32( )/A	●	●		●	●	168
Missiles						
AIM-9D (Sidewinder)			WING STATIONS ONLY (USMC)			190
Gun Pods						
SUU-11A/A (7.62mm Minigun)	●	●	●	●	●	280
SUU-12/A (.50 cal.)	●	●	●	●	●	465
MK 4 Mod 0 (20mm)			●			1350
Mines						
MLU-10/B			●			465
Dispensers						
CBU-9/A			●			840
SUU-25A/A (MK 24) (8 Flares)			●			340
Aero 7E (Lazydog)	●	●	●	●	●	540
MK 5 Mod 0 (Sadeye)			●			750
Smoke Tank						
MK 12 Mod 0 (Padeye)			●			1000
Grenade Launcher						
XM13 (XM-75)	●	●	●	●	●	282
Practice Bombs						
A/A37B-3 MBR (Six MK 106 Practice Bombs)	●	●	●	●	●	399
A/A37B-3 MBR (Six MK 76 Practice Bombs)	●	●	●	●	●	276
Auxiliary Fuel Tank						
Aero 1C (150 Gallons)			●			1106

Figure 11: Initial OV-10A Armament List

designed to replace. Both Cessnas could deploy a small fraction of the armament available from the Bronco.

DIMENSIONS AND PERFORMANCE: Figure 12 provides a summary of the general dimensions of the OV-10A.

Performance

Empty Weight: 6,893 lbs

Clean Take-Off Weight: 9630 lbs

Max Gross Weight: 14,444 lbs

Max Cargo Weight: 3200 lbs*

Normal Cruise: 180 kts

V_{NE}: 350 kts

Maneuver Loading: +8 to -2 ½ Gs

Max Ceiling: 28,000'

Cruise Fuel Consumption: 600 lbs/hr

Take-Off Minimum Speed: 85 kts with 20^0 flaps 10,000 lb gross weight

*With rear seat and associated flight controls removed

SPECIAL EQUIPMENT: Marine Corps airplanes are equipped with a capability to deliver up to six paratroops from the cargo bay with the rear cockpit accommodations removed or four with the rear cockpit retained.[30] The cargo bay is equipped with a jump light and a static line. The cargo bay door must be removed for parachute operations. Marine Corps OV-10s are equipped with a message drop door in the floor of the aft cockpit. Air Force airplanes came equipped with a KB-18A strike camera located at the message drop location. Air Force airplanes have a smoke generator system installed to aid visual airplane contact. This feeds oil into the left engine exhaust to create a white smoke trail. Later, all Marine airplanes were equipped with a smoke generator, a second VHF/FM radio, and

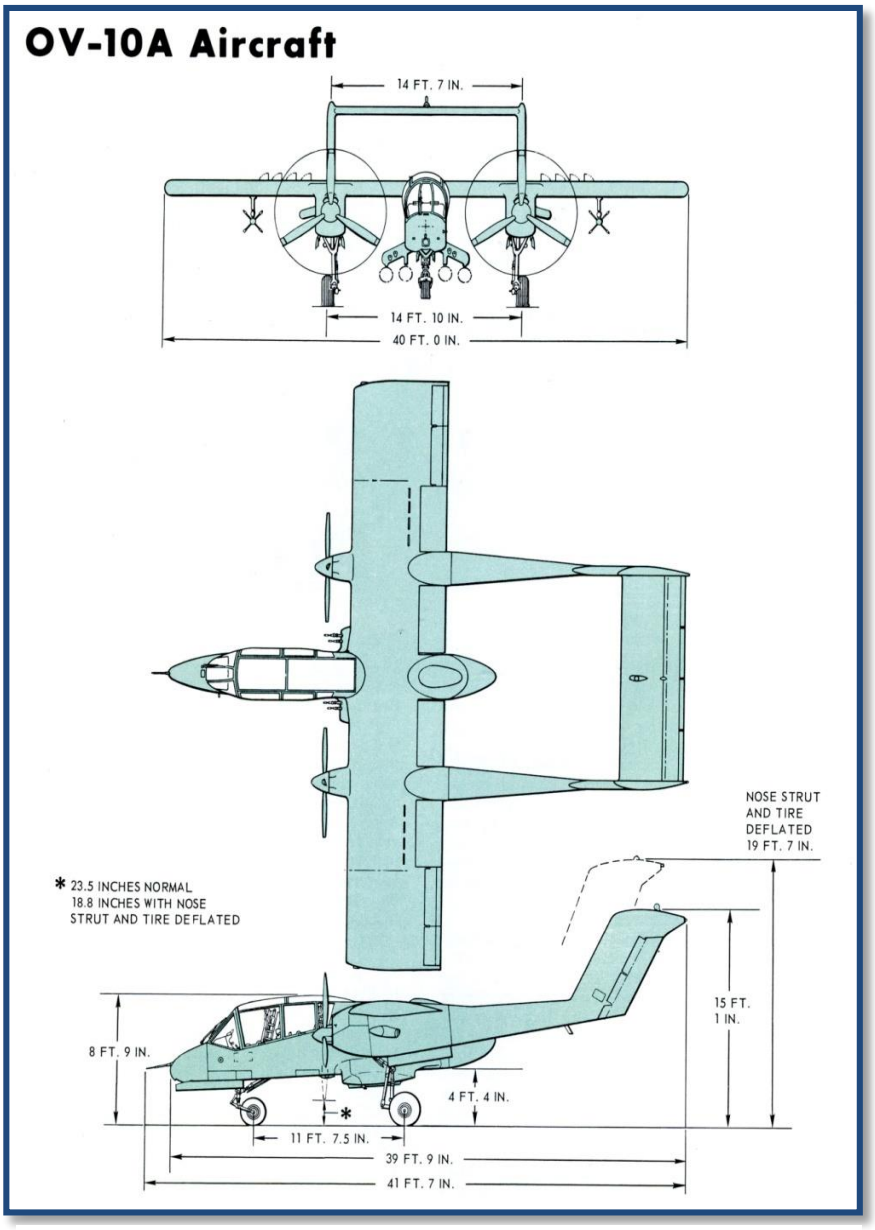


Figure 12: OV-10A Basic Dimensions

[30] Charles Burin, 2015

some were fitted with a strike camera in place of the message drop door in the aft cockpit floor.

SHIPBOARD CAPABILITY: The OV-10A design specification required it to be capable of operating off CV aircraft carriers and LPH helicopter assault ships. In support of this

Figure 13: OV-10A Being Waved Aboard

requirement the airplane is equipped with an angle of attack approach indicator and nose wheel steering. The OV-10 is not equipped to make arrested tail hook landings but can land on carrier decks by approaching at low speed and using reverse thrust and brakes to stop. Shipboard operational capability was verified in a series of flight tests conducted through July and August 1969, depicted in Figure 13. The final test report states that the airplane met all its shipboard capability specification requirements and the airplane was suitable for shipboard operations. It recommends that a Fresnel lens landing aid be used along with an angle of attack indexer in the airplane for carrier landings. [31]

OV-10A Bronco Procedures

OV-10 unique procedures are addressed below.

SPIN RECOVERY: Both NATOPS and Dash 1 flight manuals suggest that intentional upright spins are to be avoided. Spin recovery procedures are conventional and the airplane will usually recover with relaxation of controls to a neutral position and symmetrical power settings. However, the inverted spin recovery procedure is described as "…unorthodox, but not unsafe". In the event of entering an inverted spin, the pilot is directed to shut down both engines to obtain a symmetrical power condition and to avoid over temping an engine. After the rotation is stopped using conventional anti spin controls, the pilot is then directed to return to level upright flight and quickly start both engines.

ENGINE AND PROPELLER CONTROL: The engine and propeller are controlled by a single lever for each engine to simplify operation. These are called power levers. Placing the power levers full aft engages reverse thrust. Beside the power levers are condition levers that are linked to the engine management and propeller control systems. The condition levers have four distinct positions; from forward: Takeoff and Land, Normal Flight, Fuel Shutoff, and Feather and Fuel Shutoff. Selection of the takeoff and land position accelerates the engine core up to maximum RPMs for instant power lever response. The T76 engines are started in flat pitch. To ensure the propellers are in flat pitch the engines are brought into reverse thrust on shutting down to place the propellers on stop locks. After starting an engine, the propeller is placed in reverse thrust to bring it off the stop locks before attempting to taxi.

[31] Maj J.M. Dye, USMC, J.M. Rebel, Naval Air Test Center Technical Report, "*Final Report, Shipboard Suitability Evaluation of the OV-10A Airplane",* NAS Patuxent River, MD, 23 October 1969

5. Fielding the OV-10 in Vietnam

The Marine Corps and Air Force both took delivery of their first OV-10A at Columbus Ohio on 23 February, 1968. The initial delivery was 18 months later than expected because of engine and control issues. The last delivery to the Marine Corps was made on 19 February 1969 with a total of 114 delivered and the last Air Force delivery was made on 15 April 1969 for a total of USAF 157 OV-10As.[32]

The Marine Corps introduced the OV-10 to Marine Observation Squadrons or VMOs that had already been operating in-country with O-1s and UH-1Es. The Air Force planned to replace both O-1 and O-2 aircraft operating in Southeast Asia in Tactical Air Support Squadrons, or TASSs. The Navy would later accept the transfer of eighteen Marine OV-10As to equip a new squadron being formed in the Mekong Delta region to support riverine operations. The Bronco had arrived. OV-10 unit deployment sites and operating areas are shown in Figure 21.

5.1 Marine Corps Service

Marine Corps OV-10s were to be used in various missions including reconnaissance, forward air control, cargo transport, troop transport, litter transport missions, and paratroop airdrop missions.[33] This list was later expanded and modified to include visual reconnaissance and artillery/naval gunfire adjustments. Special missions included but were not limited to helicopter escort, convoy escort, search and rescue (SAR), sensor delivery, illumination flare drops, and light cargo transportation.[34] Direct attack using OV-10 armament in support of all these missions was implied. A key contributor to the successful use of Marine Corps OV-10s was the AO, or Aerial Observer flying in the back seat.

The totality of the Marine Corps OV-10A missions was condensed to the term, Tactical Air Control, Airborne; or TAC (A). The TAC (A) mission was the coordination of various assets such as supporting arms, fixed wing air, helicopter transports and gunships, and medivac helicopters in a single scenario in support of troops on the ground.

Figure 14: Marine Corps OV-10 Training Mission

For many pilots, familiarization and qualification in the new airplane prior to deployment was accomplished at VMO-5 later re-designated as HML-267 located at Marine Corps Base Camp Pendleton, California. The Marine Corps transferred aircraft to two squadrons to begin

[32] Charles Burin 2015

[33] *Preliminary NATOPS Flight Manual, Navy Model OV-10A Aircraft*, NAVAIR 01-60GCB-1, 15 May 1968

[34] *Tactical Manual, Navy Model OV-10 Aircraft,* NAVAIR 01-60GCB-IT, 15 June 1974

OV-10 operations in Vietnam. These were VMO-2 and VMO-6 both operating in I Corps.

VMO-2

Marine Observation Squadron Two (VMO-2), call sign "Hostage", assigned to Marine Air Group 16, July 1968* – February 1970 at MCALF Marble Mountain, Vietnam and to Marine Air Group 11, February 1970 – March 1971 at DaNang AB, Vietnam (*initial OV-10 Deployment)

The first VMO-2 aircraft deployed to Vietnam as a detachment with HMM-362 in April 1962. Three OE-1 Birddogs flew off the USS Princeton for Soc Trang, South Vietnam to join HMM-362. After several months the Marines were moved north to Da Nang switching places with the Army H-21 squadron. VMO-2 sent four additional OE-1s to the squadron in late 1962. They were joined by the rest of VMO-2 in May 1965 as part of the 9th Marine Expeditionary Brigade and were based at MCALF Marble Mountain, Quang Nam Province, Vietnam.

The first OV-10As joined the squadron on 6 July, 1968. The six aircraft flew to MCALF Marble Mountain from NAS Cubi Point, Philippines and in less than three hours the first combat mission was flown in aircraft 155413. The VMO-2 OV-10 mission was to provide direct air support for the 1st Marine Division in their expanded Tactical Area of Operations which went from Hai Van Pass north of DaNang to the Que Son Mountains west of Hoi An and west to the Laotian border. The VMO-2 Broncos also provided the same support for the 3rd Marine Division prior to the OV-10 being available to VMO-6 and again after VMO-6 had redeployed to Okinawa. During these periods the squadron's OV-10s operated from the Que Sons north to the DMZ. Missions in support of Marine and allied forces included observation, artillery and naval gunfire spotting, TAC (A), armed helicopter escort, smoke screen cover for landings and extracts, convoy escort, as well as radio relay missions for Marine Division and Force Reconnaissance teams

A unique feature of VMO-2 was the use of personal call signs combined with the squadron call sign, Hostage, in place of the numbers used by other FACs. It started with the phonetic alphabet but quickly ran out of letters. Pilots then were able to select names that were approved, in writing, by the Commanding Officer. The call signs were used on the published flight schedule and for all aspects of flight operations. The names, such as Hostage BEEFEATER, Hostage BEAR, Hostage DRAGON, Hostage LADY, Hostage JUNKMAN, Hostage SIX, and Hostage IGOR became easily recognizable to ground troops as well as the fighter and bomber pilots being controlled by Hostage crews.

The usual daily flight schedule had 25 missions assigned by the wing per day. The standard mission was providing a Bronco in the air over the division operating area from just before sunrise to just after sunset every day if weather permitted. Weapons load for these standard support missions was usually two 7 shot pods of 2.75 inch WP rockets and two with 2.75 inch HE rockets as well as the four sponson M60 7.62mm machine guns.

In 1969 VMO-2 supported US Navy riverine forces around Hoi An, south of DaNang, controlled naval gunfire from the USS New Jersey, and conducted a fifteen hour evaluation of the XM-76 Dynalens Anti-Oscillating Sight

System. It was less than successful causing many of the Aerial Observers to become air sick because the target didn't move when the aircraft maneuvered causing a conflict in perception between the eye and the inner ear. Also in 1969 VMO-2 began a brief period where pilots were exchanged with the Navy OV-10 squadron VAL-4 at Vung Tau. In April the squadron received the first four of twenty four AH-1G Cobras. The combination of UH-1Es, AH-Gs and OV-10s made the squadron one of the largest in the Marine Corps. By December 1969 all the VMO-2 UH-1Es and AH-1Gs had been transferred to squadrons who specialized in operating those aircraft and the squadron became an all Bronco operation. Before the end of the year VMO-2 added to its missions the deployment of Air Delivered Seismic Intrusion Devices (ADSIDs).

In early 1970 VMO-2 moved from MAG-16 at MCALF Marble Mountain to MAG-11 at DaNang AB. That February VMO-2 first used the GPU-2 20mm cannon gun pod mounted on the centerline station. This led to a new gunship configuration with four M60 internal machine guns, two SUU-11 miniguns, the 20 mm gun pod and two seven shot 2.75 inch WP pods. A night stand-by package was established for recon team extraction utilizing one OV-10A with forty MK-45 flares and a second OV-10 to provide TAC (A) support. 150 gallon external centerline fuel tanks were installed on several aircraft to extend time on station up to four hours for specific missions. In May 1970 VMO-2 made several practice parachute inserts with 1st Force Reconnaissance Company near Hai Van Pass. In support of *Operation Thrash Light* OV-10s were armed with Zuni 5 inch rockets. *Thrash Light* involved the Marine CH-53s acting as bombers carrying twenty 55 gallon drums of napalm in cargo nets. The helicopters released the drums over double and triple canopy jungle above a suspected base area south of Thoung Duc and the contents were ignited by OV-10 rocket fire. An addition to the OV-10 weapons inventory, the CBU-55 low speed fuel air explosive weapon was field tested in late 1970

21 March 1971 VMO-2 flew its last combat missions in Vietnam. Before leaving for the U.S. they transferred four aircraft to H&MS-11 for continuing Vietnam service. H&MS-11 flew OV-10s for an additional 207 sorties and 457.5 hours in support of U.S. and allied forces.

During their 33 months of combat VMO-2 flew 17,215 sorties and 38,218 hours in the OV-10 Bronco. Six OV-10s were lost along with nine crew members. Returned to the US, VMO-2 resided at Camp Pendleton, California until the squadron was decommissioned in 1993.[35]

VMO-6

Marine Observation Squadron Six, call sign "Seaworthy", Assigned to Marine Air Group 36, November 1968* – October 1969, Quang Tri, South Vietnam (* Initial OV-10 Deployment)

VMO-6 followed VMO-2 in introducing the OV-10 into a squadron that was already operating UH-1E gunships and O-1Cs in Vietnam. Broncos were flying missions supporting Marines starting in November 1968. Crews performed visual reconnaissance, FAC, and artillery control and naval gunfire spotting missions. VMO-6 began with ten OV-10s assigned in November rising to fourteen aircraft in January 1969 and completing

[35] Charles Burin 2015

the total of eighteen OV-10s in April 1969. The squadron operated in support of 3rd Marine Division units and participated in *Operation Dewey Canyon*. They also flew in support of U.S. Army units located in I Corps.

TheVMO-6 operating area was the Quang Tri Province area immediately south of the DMZ that included the former airfield and fire support base at Khe Sanh near the northwest corner of South Vietnam adjacent to the border with Laos. Typical missions included support of troops-in-contact and visual reconnaissance (VR) along with command and control of supporting arms and coordinating reconnaissance force inserts and extracts. VR missions were routinely flown looking for enemy movement in the myriad road and trail networks leading down from North Vietnam and across from Laos, often referred to as the Ho Chi Minh Trail. In 1969 VMO-6 OV-10s were routinely armed with sponson mounted M60 7.62mm machine guns with 2000 rounds of ammunition and either twenty eight 2.75 inch rockets or eight 5 inch Zuni rockets.[36] Marginal weather was always a factor when terrain varied from the sea coast to rolling hills and mountains.

Through their tenure in combat, VMO-6 completed 4,878 OV-10 sorties while accumulating 11,000 flight hours with losses of three OV-10As and two crewmembers KIA. VMO-6 was re-assigned to MCAS Futema, Okinawa in October 1969. The squadron continued to support operations in Vietnam and in the spring of 1972 was placed on four hour alert for deployment back to the combat zone. After two days the alert order was rescinded.[37]

Figure 15: Marine Corps OV-10A in Vietnam with CBU-55s.

[36] Bob Whaley 2015

[37] Lt Col Gary W. Parker, Jr, Maj Frank M. Batha *A History of Marine Observation Squadron Six*, History and Museums Division Headquarters, U.S. Marine Corps, Washington DC, 1982

The squadron remained on Okinawa until decommissioning at the end of 1976.

Marine Corps Operational Use

On combat missions the OV-10 crew would be tasked with a support mission by the Marine Corps Direct Air Support Center or DASC for that operating area. On initial contact, DASC would relay the supported unit call sign, the radio contact frequency, the map grid, and the reason for the call for help along with all de-confliction or "save-a-planes" along the route of flight. This de-confliction of live artillery, naval gunfire missions, ongoing ARCLIGHT, mini-ARCLIGHT, and close air support (CAS) air strike missions in-progress was a necessity for every mission in direct support of Marine ground units. When operating in an US Army Tactical Area of Operations (TAOR), the Marine Corps no longer controlled this critical de-confliction role and the Army's "Big Sky-Little Bullet" philosophy prevailed. [38,39]

As with other combat flights in Vietnam, Marine Corps OV-10 operations were constrained by the Rules of Engagement, or ROE. The constraints placed upon aircrews were generally extremely frustrating, For example, you couldn't "shoot first and ask questions later," even if you had the enemy troops clearly in sight. Before launching, Bronco crews were given the daily intelligence brief by the S-2, and the movements of enemy units across the map of the squadron operating area could be predicted by identifying which grid squares were "no fire" and "free fire" zones. Typically, the Vietcong or North Vietnamese Army formations were always located in the "no fire" zones, and their location could be visually confirmed. The only time you could engage them is if they were foolish enough to shoot at you first, and even then in 1971, you had to secure permission to return fire.[40] Earlier in 1968-1970 it was permissible to return fire when engaged by the enemy without additional authorization.[41]

Figure 16: ADSIDs Loaded For OV-10 Delivery

Due to the versatility of the OV-10, it was often requested by units outside the chain of command to support a variety of non-direct support missions. Support of the Americal Division at Chu Lai and sensor drops in the Ashau Valley for 101st Airborne Division had begun as early as 1969.[42] In 1970-1971 outside missions included dropping and plotting acoustic sensors for the 101st Airborne Division, experimental dropping of CBU-55s in combat operations for analysis by NWC China Lake ballistic scientists, and using a jerry-rigged 26 pound laser designator controlling the first laser-guided bombs employed by the U.S. Air Force in combat.

In close air support (CAS) missions, the particular expertise of Marine Corps air support, the pilot and AO were authorized to run CAS as long as one of them had been designated as TAC (A) qualified. Attack aircraft had to use a run-in

[38] Mike McCollum, 2015
[39] ibid.
[40] Gordon Evans 2015
[41] Charles Burin 2015
[42] ibid

azimuth parallel to friendly units, and pull off target in a direction that would keep the bomber around the friendly unit, in the event a bomb or napalm canister failed to release on time. 500 pound bombs and full canisters of napalm were occasionally "thrown" a click or more away from a friendly ground unit, because of a malfunction of the bomb release mechanism.[43]

It was critical to observe the run-in of aircraft under control on a close air support mission as it came "down the chute-in hot" to assure the bombing run was parallel to friendly units. The CAS aircraft was "cleared hot" only after the aircrew observed it on the correct azimuth coming down "the chute". [44]

On Vietnam combat missions, in direct support of Marine ground units the OV-10 crew shared control of the mission and AOs advised the pilots where to fly and who to shoot or not shoot. Pilots owned the airplane, did all the flying and the shooting for the AOs did not touch the flight controls. The AOs would maintain constant radio contact with supported ground units via the two VHF/FM radios, while the pilots maintained constant radio contact with aircraft and the "Guard" frequency via the UHF radios. The OV-10 aircrew was truly the "Marine Air/Ground team" in action. [45]

The Aerial Observer, or AO

The AO is a Marine Corps officer who occupies the backseat of an OV-10 and has previously been trained to be a ground officer. AOs have been a part of the Marine Corps aviation operational scheme since WWI when Gunner Robinson was awarded the first USMC aviation Medal of Honor and in WW II when AO artillery officers occupied the back seats of VMO OY-1 and TBF/TBM aircraft in such battlefields as Iwo Jima and Okinawa. They later served in Korea in OY-1 and O-1 fixed wing airplanes as well as VMO-6 helicopters.[46]

The Vietnam OV-10 crew member AO might be flying with either of the Marine VMO squadrons. For VMO-2, AOs came from the 1st Marine

Figure 17: OV-10 Back Seat View Forward

Division and their unit call sign was Cowpoke supporting 1st MARDIV units. AOs were assigned from the 3rd Marine Division supporting 3rd MARDIV units with VMO-6, call sign Seaworthy.[47] The AO might otherwise be assigned to control

[43] Mike McCollum 2015
[44] ibid
[45] ibid
[46] Mike McCollum 2015
[47] Tim Moriarty 2015

naval gunfire missions in an Air Force OV-10 or a Navy OV-10 as well as in an O-1 of the U.S. Army or Korean Marines.

The Marine Corps air ground team was personified in the OV-10 cockpit during in Vietnam. By the time of the arrival of the OV-10, the Aerial Observer's Military Occupational Specialty (MOS) 0805, was in addition to the their existing primary MOS. To receive the MOS, a ground officer volunteer normally was ordered to the Marine Corps AO school at MCAS New River, North Carolina following one or more tours of duty in his primary job. The school lasted approximately two months and included training in controlling artillery and naval gunfire from a moving airborne platform, high angle, low angle and vertical aerial photography, all the possible air and ground radio networks and proper secure radio communication procedures, ground reconnaissance patrol coordination procedures, dead reckoning skills, basic nomenclature of the OV-10, and flight standard procedures. As experienced ground officers, AOs were already very familiar with 1:50,000 tactical maps; they received additional familiarization with 1:250,000 aviation maps, emergency landing procedures, and a very short session on escape and evasion (E&E). Most OV-10 flight crews including AOs assigned to service in Vietnam attended the formal three day E & E school at NAS Cubi Point, Philippines early in their respective tours.

The AO School produced just three classes per year of no more than twelve students in each class. To make up for a shortfall in AOs, those trained in other skills were offered training including those with armor, and engineer, and other MOSs. Many AOs during the Vietnam War received the training at the temporary AO School at MAG-16 at Marble Mountain after serving a tour as a platoon, company, or battery commander.

Figure 18: Marine Corps OV-10 in Vietnam. Note the crew visibility and vulnerability.

Unlike pilots assigned to a specific squadron, most AOs would serve six months with the AO section, then return to their parent ground unit while others finished the second half a twelve or thirteen month WestPac tour with additional time as an AO.

Although the concept of the Air/Ground team in the Bronco was based on the philosophy that the AO brought into the cockpit intimate knowledge of ground operations often times the Marine pilot knew these subjects as well or better, having spent a previous tour as a ground FAC, or having been a ground officer prior to going to flight school.

AOs received no formal training on piloting the aircraft[48] and there were no missions ever requiring the AO to take the controls of the OV-10, yet pilots encouraged AOs to learn to fly and, when possible, allowed AOs ample "stick time". This was out of necessity because the ejection system did not allow the AO to eject the pilot, but when the pilot ejected, he automatically ejected the AO first. And while the OV-10 was difficult to hit with ground fire the pilot was the more vulnerable crewmember. He sat in the front seat with his upper torso surrounded by 220 degrees of canopy. If a lone enemy rifleman got lucky and the pilot took a hit and was incapacitated, he wanted to be sure that that the AO could land the airplane. This vulnerability is illustrated in Figure 18.

Figure 19: Marine Corps OV-10A in Vietnam, 1969

[48] Mike McCollum, "This gap in the AO School syllabus was eventually corrected, but it was after the last Marine OV-10 left RVN". 2015

Marine Corps OV-10 in Combat

The magic of the Marine OV-10 aircrew was that two officers worked together at 700' to 1000' above the ground or lower. The stress on OV-10 pilots during troop-in-contact (TIC) missions was extreme because often the pilot was required to put down strafing rounds within 10 meters of unprotected friendly units, often a recon team. During OV-10 armament use, the pilot was the key crew member. The AO's job was to assist him in avoiding fratricide by constantly monitoring elevation, azimuth, target location, terrain and continuously talking to the ground troops as the ordinance was being delivered. [49]

Azimuth watch by the crew was a critical task. The AO would lean left or right, look around the pilot as he flew down the chute, to assure he had the friendlies at either the 9 or the 3 o'clock positions. If this was not clearly apparent, it was the AO's job to give the command: "Abort, Abort, Abort" before the pilot fired. In addition, it was the AO's job to coordinate with the supported unit to: (1) tell them when the plane was "in hot", (2) advise them as to ammo status and time left on station, and (3) forward to the pilot via intercom all reports of location and caliber of enemy fire being directed at the plane while the pilot was concentrating on his placement of onboard ordnance. [50]

Marine Corps OV-10 Official Operational Evaluation

The Marine Corps First Marine Air Wing evaluated the OV-10 in combat in Vietnam over a period from 15 September 1968 through 15 October 1968. All flights were flown in support of III MAF units in I Corps from bases at Quang Tri and Marble Mountain. The general conclusion was that the airplane was reliable and mission capable. It was evaluated on target acquisition, artillery spotting, reconnaissance, photography, TAC (A), and target marking capabilities and found to be excellent in maneuverability, visibility, weapons carriage and delivery, and helicopter escort missions. Demonstrated survivability was good with additional armor for crew protection advised.

Figure 20: VMO-2 OV-10A DaNang, 1970

[49] Mike McCollum 2015

[50] Mike McCollum 2015

Serious complaints were that the OV-10 was under powered, needed another VHF/FM radio for artillery spotting, needed a way for the AO to eject the pilot, and needed a cockpit air conditioning system.[51] Because of the lack of cockpit air conditioning, typical missions in Vietnam were limited to two hours and fifteen minutes in consideration for the crew.[52] Eventually a second VHF/FM radio was added.

Marine Crew Observations

The majority of Marine OV-10 crews who flew in Vietnam and afterward have appreciated the many favorable aspects of the airplane. It is universally praised for its maneuverability, short landing capability, and simple ruggedness. It's a versatile airplane that does many things well and is fun to fly. However, there were areas that needed to be improved.

Marine Corps OV-10 crews in Vietnam repeatedly described the lack of cockpit air-conditioning as a major flaw in the airplane. Although the aircraft was designed with Vietnam service in mind, crew comfort was clearly not a priority. The minimal overhead cockpit vents only served to direct the hot and humid ambient air into an already roasting cockpit, and were primarily used to suck out cigarette smoke and ashes when turned backwards. The superior visibility provided by the "fishbowl" canopy also insured that crews would be baked during the usual mission. The VMO-2 squadron flight line shack had an upright freezer that held dozens of plastic quart canteens that were solid blocks of ice. Both crewmen would take four bottles apiece. It was not uncommon to return some three hours later with canteens empty, flight suits wringing wet and having lost two or three pounds.[53]

It was observed that by 1971 the Marine OV-10 aircraft in Vietnam were tired but kept in remarkably good shape by experienced and dedicated maintenance personnel. The Marine Corps Bronco was flown hard in some terrible environmental conditions and the dispatch/reliability rate was outstanding.[54]

Not mentioned in the official evaluation was the adverse effect high temperatures had on engine performance. The combination of high airport altitude and high temperatures degraded engine performance. This slowed takeoff acceleration and reduced the contribution the propeller wash over the wing gave to lift and takeoff performance. Drag from external stores made this condition worse and contributed to long takeoff rolls and the risk of control loss if an engine failed during takeoff. Luckily airfields in Vietnam were not usually at high altitude; just summer time scorching hot.[55]

[51] *Marine Corps Combat Evaluation*, 1stMAW, undated
[52] Charles Burin 2015
[53] Gordon Evans 2015
[54] ibid
[55] Ashby Shoop 2015

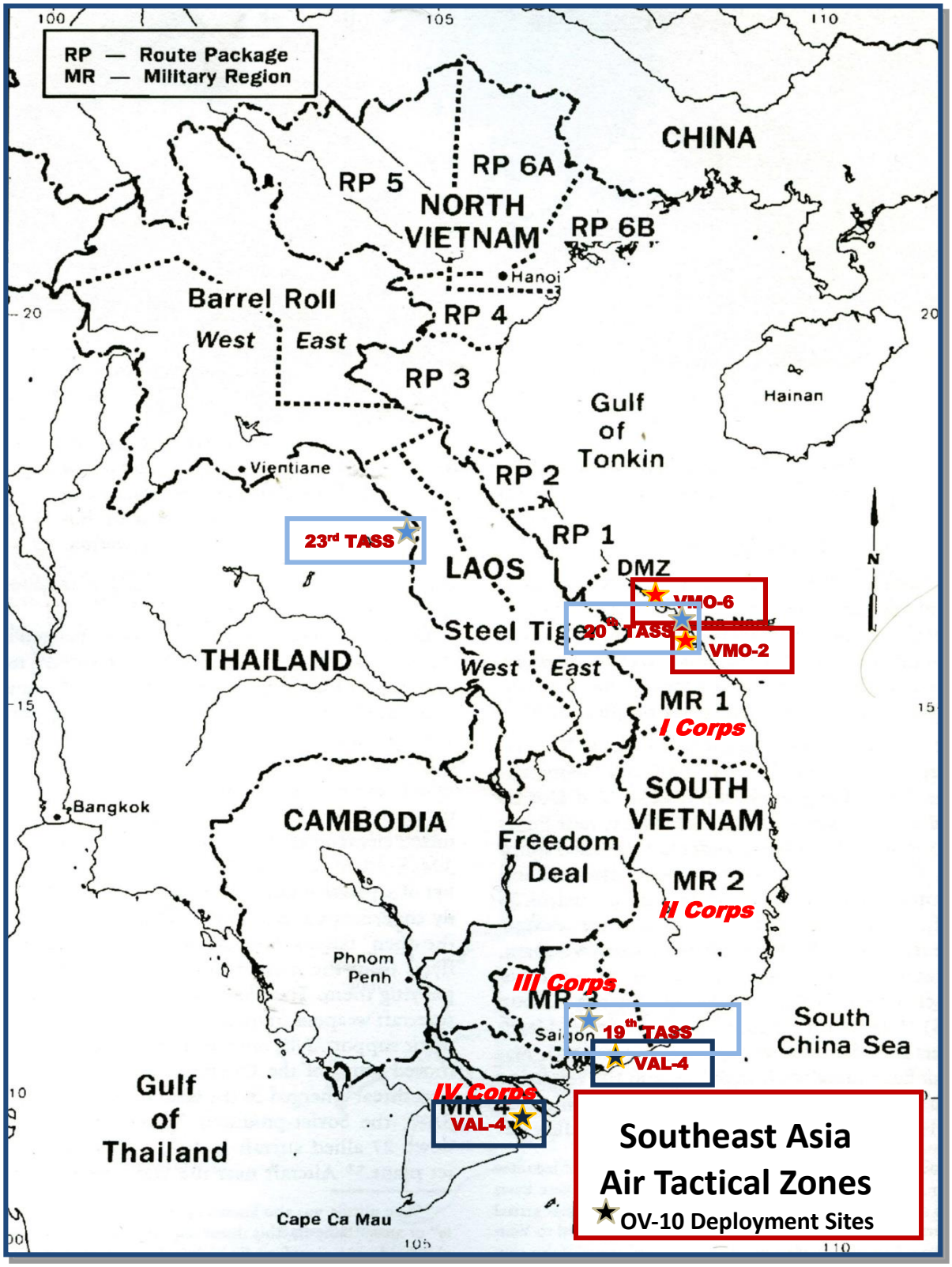


Figure 21: SEA OV-10 Squadron Locations

Map from *U.S. Marines in Vietnam, The War That Would Not End 1971-1973*, USMC History and Museums Division 1991

5.2 Air Force Service

Air Force OV-10s were introduced into existing units in Southeast Asia to replace O-1s and O2s for use by forward air controllers (FACs). In Vietnam per the ROE nearly every aircraft delivered bomb or rocket was required to be under the control of a FAC.[56] OV-10s were expected to be used in controlling fighter aircraft in support of troops on the ground and in controlling fighter aircraft on interdiction missions.

The *Combat Bronco Program* conducted with the 19th TASS beginning in September 1968 for approximately 60 days[57] used the first six USAF OV-10s delivered to SEA to evaluate Bronco effectiveness in a FAC role. The study remarked that for the first time a FAC had provided his own illumination in a night FAC mission. Although forward air control was the primary mission, it was reported that initial Air Force mission types included visual reconnaissance, radio relay, convoy escort, air/ground coordination, artillery adjustment, and CS gas-expenditure control. Aircraft were operated from forward operating locations (FOLs) in austere conditions supporting both the 1st Infantry Division and the 25th Infantry Division.[58] It was ascertained that at normal operating gross weight a minimum 3000' runway was required. Over 1000 hours and 552 FAC and VR sorties were accomplished without accident or incident. Both the Army leaders of units being supported and Air Force commanders stated that support capability was excellent. The OV-10 proved to be a satisfactory weapon system for controlling airstrikes in part due to its maneuverability. Availability rate was observed to be 89 percent and the operational ready rate was 93 percent predicting that the OV-10 system would be better than any other already fielded in Vietnam. The *Combat Bronco Program* was so successful in proving the

Figure 22: Air Force OV-10A

[56] LCDR Andrew R. Walton, *The History of the Airborne Forward Air Controller in Vietnam*, Ft Leavenworth, KS, 2004

[57] Capt D.J. Sultany USAF, Report on Combat Bronco, 9 December 1968

[58] Capt D.J. Sultany USAF, Report on Combat Bronco, 9 December 1968

capabilities of the OV-10 platform that deliveries were quickly made to other the tactical air support squadrons.[59,60]

The *Misty Bronco* evaluation looked at the value of arming OV-10s to respond to troop-in-contact situations with armament to include M60 machines guns, HE and WP 2.75 inch rockets, and flares for night missions. The study demonstrated that the FAC mission was not compromised with the addition of armament but rapid and effective response for troops-in-contact situations was available when tactical aircraft were not on scene and immediate action required. Jet fighters took approximately 40 minutes to respond to support requests when standing ground alert. Airborne diverts of fighter aircraft to missions of a higher priority took 10 minutes. An airborne controller with armament could respond to urgent requests in 5 minutes that expanded to 8.7 minutes when attacking fleeing targets.[61] The OV-10 proved itself particularly valuable in the armed FAC role addressing support opportunity against small fleeing targets.[62] Arming of all USAF OV-10s was authorized on 5 June 1969[63,64] with 2.75 inch HE rockets and M60 machine guns being the common USAF FAC load in addition to WP rockets for target marking.[65]

Training for Air Force OV-10 pilots was provided by the 4409th Combat Crew Training Squadron at Hurlburt Field, Eglin AFB, Florida and by the facility at Phan Rang known as the forward air control university, or FAC (U). Air Force OV-10 operating units were distributed throughout the Southeast Asia theater of operations as shown in Figure 21. Although these were the main operating bases for the identified squadrons, elements were deployed at FOLs to support specific units or missions. Air Force units operating OV-10s on combat missions deployed in Southeast Asia are the 19th, 20th, and 23rd TASS. The 21st TASS had OV-10s transferred to it late in the war from the 19th TASS to support Rustic Cambodia operations but soon transferred that responsibility to the 23rd TASS.

Augmenting Air Force crews flying the OV-10 FAC mission in Vietnam were pilots from Australia and New Zealand provided as a part of those nation's contributions to fighting the war. Between 1968 and 1970 thirteen RAAF OV-10 pilots were assigned to the 19th TASS and from 1970 through 1971 seven RAAF OV-10 pilots were assigned to the 20th TASS. Additionally six RNZAF OV-10 pilots were assigned in USAF FAC squadrons; three in the 19th TASS and three in the 20th TASS. Other RAAF and RNZAF pilots flew O-1s or O-2s in support of U.S. and Australian units.[66]

The Air Force lost a total of 64 OV-10As in Southeast Asia. Bronco FACs sustained 46 crew members lost, five became POWs, and 49 survived the loss of the airplane.[67]

[59] Capt D.J. Sultany USAF, Report on Combat Bronco, 9 December 1968
[60] CHECO Report, *OV-10 Operations in SEAsia*, 15 September 1969
[61] Lt Col Ralph A. Rowley, *Close Air Support in Vietnam*, Defense Lion, 2013
[62] *Case Studies in the Development of Close Air Support*, Office of Air Force History, 1990
[63] CHECO Report, *OV-10 Operations in SEAsia*, 15 September 1969
[64] The Air Force In Vietnam: *The Administration Emphasizes Air Power 1969*, Office of Air Force History, November 1971
[65] Lt Col Ralph A Rowley, *Air Support in Vietnam*, Defense Lion, 2013
[66] Peter Condon, Darryl McEvedy, Ken Semmler 2015
[67] Chris Hobson, *Vietnam Air Losses*, Midland, 25 February 2002

19th TASS

19th Tactical Air Support Squadron, Call Sign "Drama", "Issue", "Pretzel", "Rash", "Ringo", "Rustic", "Sidewinder", "Slugger", Assigned to the 504th TASG, August 1968* - January 1972, Bien Hoa, South Vietnam (* Initial OV-10 Deployment)

The 19th TASS was the first Air Force unit to employ OV-10s in SEA combat receiving the first six in August 1968. The first flight of an Air Force OV-10 in Vietnam came on 8 August 1968 in aircraft 67-14619. This and the other initial six 19th TASS aircraft had been carried inside a C-133 flown from the U.S. to Vietnam with the airplanes broken down. Later deliveries were of completely assembled airplanes transported by ship because it took less time to prepare them for flight.[68]

The squadron hosted the *Combat Bronco* and *Misty Bronco* evaluations. Located in Military Region 3 or III Corps, deliveries of airplanes continued and operations commenced from FOLs in support of U.S. forces including units of the 1st Cavalry, the 5th Special Forces Group, the 199th Light Infantry Brigade and other the 25th Infantry Division units, the. 1st Infantry Division, and others. The 19th TASS provided the initial support to Rustic FACs operating in Cambodia.

Australian crews assigned to the 19th TASS flew in support of the U.S. 1st Infantry Division, the 199th Light Infantry Brigade of the 25th Infantry Division and the 1st Cavalry. New Zealand pilots in the 19th TASS flew in support of the 25th Division and its 199th Light Infantry Brigade.[69]

The squadron lost a total of sixteen OV-10As during service in Vietnam with ten crew members KIA. The squadron was deactivated on 19 January 1972. An additional airplane was lost while listed as a 21st TASS OV-10 after transfer of the 19th TASS Rustic assets and prior their transfer to the 23rd TASS.

20th TASS

20th Tactical Air Support Squadron, Call Sign "Covey", "Barky", "Helix", Assigned to 504th TASG, January 1969* – January 1973, DaNang, South Vietnam (* Initial OV-10 Deployment)

In January 1969 the 20th TASS received its first OV-10A, having been operating from DaNang since August 1965 with O-1 and O-2 aircraft. By October 1969, 20th TASS operated from a main base and eleven forward operating locations in Military Region 1 or I Corps, supporting five U.S. Army and six South Vietnamese Army forces locations for such units as the 5th Infantry Division. U.S. Armed Forces gradually withdrew from South Vietnam in 1970-1972, and the 20th TASS discontinued its FOLs in 1971 and early 1972. FOLs were reestablished when North Vietnamese forces invaded the south in April 1972. In June 1972 it flew three times the missions it had in March, prior to the invasion. In addition to FAC, liaison, observation, and reconnaissance missions, the 20th TASS provided

[68] Capt D.J. Sultany USAF, Report on Combat Bronco, 9 December 1968

[69] Peter Condon, Darryl McEvedy, Ken Semmler 2015

base defense with the OV-10A aircraft equipped with small bombs, 2.75 inch rockets, and 7.62mm guns in response to enemy rocket attacks on DaNang AB. Seven RAAF OV-10 pilots assigned to the 20th TASS flew in support of the U.S. 23rd Infantry Division. Three RNZAF pilots in 20th TASS also supported the 23rd Infantry Division.[70]

Notably 20th TASS shared FAC mission duties with Nail FACs of the 23rd TASS during the *Bat 21* rescue. During one 20th TASS OV-10 mission late in the war the airplane was struck by an SA-7 shoulder fired missile. To save the observer, a Marine AO who had a shredded parachute precluding ejection, the pilot elected to attempt a ditching which resulted in the death of the pilot. Captain Steve Bennett earned the Medal of Honor, the only OV-10 crewmember to be so recognized. His daughter, Angela Bennett-Engele, is the current president of the OV-10 Bronco Association.

The squadron lost a total of 22 OV-10As sustaining 22 crew members KIA and three POWs. In January 1973, the squadron discontinued its last forward operating location, flew its last mission, and transferred its OV-10As to other USAF squadrons in Southeast Asia. The squadron was reactivated at George AFB, California and later saw service in Germany and South Carolina before being finally deactivated at the end of 1991.

23rd TASS

23rd Tactical Air Support Squadron, Call Sign "Hammer", "Nail", "Spike", "Rustic" Assigned to the 504th TASG, 1969* – October 1975, Nakhon Phanom and Ubon, Thailand (* Initial OV-10 Deployment)

The 23rd Tactical Air Support Squadron was created out of Detachment 3 of the 505th Tactical Control Group on 15 April 1966 for operations in the Steel Tiger portion of the Ho Chi Minh Trail between Nape Pass and Tchepone area in the Lao Panhandle. The unit was initially called Operation Cricket, which was the name the area airborne control ship took for a call sign, and the original pilot call sign was "Gombey". This was changed to "Nail" in mid-1966, and Nail remained a unit call sign until the end of the war. The 23rd TASS well-known unit patch was Jiminy Cricket, equipped with a walkie-talkie and an umbrella. The image was sold to the squadron by Walt Disney for $1 in response to a request from a Nail pilot.

In 1969 the 23rd TASS began to receive OV-10 Broncos to augment and replace the O-1 and O-2 aircraft the squadron had been operating. The OV-10 was flown until the end of the war. The 23rd TASS primarily engaged in flying interdiction missions along the Ho Chi Minh trail. They controlled air strikes on trucks and personnel, and occasionally deployed aircraft in support of special operations missions.

[70] Peter Condon, Darryl McEvedy, Ken Semmler 2015

Part of the squadron was committed to operations in Cambodia between June 1970 and August 1973. They were recognized by the call sign, Rustic. This support had passed from the 21st TASS who had briefly taken it over from the 19th TASS.

Nail FACs participated in search and recovery missions (SAR) for downed aircrew including, along with Covey and Bilk FACs, the *Bat 21* operation mounted to recover Lt Col Iceal Hambleton who had bailed out of a SAM damaged EB-66. This operation was depicted in books and a film, "*Bat 21*".

On 12 April 1975 the 23rd TASS supported *Operation Eagle Pull*, the American evacuation of Phnom Penh, Cambodia. One month later the 23rd TASS participated in the last official battle in the Southeast Asian War. This was the recovery of the American flagged container ship Mayaguez and her crew by portions of the 4th and 9th Marines. Nail FACs were overhead as elements of 2nd Battalion 9th Marines battled the Khmer Rouge on Koh Tang Island. Lt Col Randall Austin commanding BLT 2/9 noted that the Nail FACs supporting him were the first air support he received on the operation that had an understanding of the situation and knew how to coordinate ground and air activities.[71]

During its assignment in Southeast Asia, the squadron lost 23 OV-10As with a subsequent crew member loss of two KIAs and two POWs. The squadron was deactivated in SEA on 30 June 1975.

Air Force Operational Use

Deployment of the OV-10 caused no new development of new Air Force FAC tactics. The methods used to acquire targets, mark them, and control strike aircraft on the targets were the same as those used in O-1s and O-2s. OV-10s shared the same basing approach that the earlier FAC aircraft had used operating from remote and austere FOLs, often in support of remote U.S. Army fire support bases. For night operations the FAC had artillery illumination available as well as on board flares. These were delivered from 3500 feet AGL in two minute intervals providing sixteen minutes of target illumination.[72]

The way for a FAC to assure survival at low altitude over hostile territory was to "jink"; varying heading and altitude continuously.

The formidable combat ability of the OV-10 as a FAC platform was due to the ability to communicate. The pilot had at his command a UHF radio with Guard, a VHF radio, two VHF (FM) radios, an FM homer, and an HF radio, and secure scrambling available on some of them. They could all be monitored simultaneously or the pilot could elect which radios to receive and which radio on which to transmit through a radio control panel.[73] Listening to simultaneous radio transmissions could be very confusing but after some experience one could sort them out by difference in sound quality.[74] Communications capability made the OV-10 the most dangerous weapon in the sky because air strikes, artillery, and naval gunfire were just a radio call away.

[71] James E. Wise Jr., Scott Baron, *14 Hour War*, Naval Institute Press, Annapolis, MD, 2011

[72] *Tactics and Techniques of Night Operations*, *1961-1970*, Office of Air Force History, March 1973

[73] LCDR Andrew R. Walton, *The History of the Airborne Forward Air Controller in Vietnam*, Ft Leavenworth, KS, 2004

[74] Ashby Shoop 2015

The VR or visual reconnaissance mission required experience and a knowledge of the area. Changes were noted along with small details such as cooking fires and laundry drying as well as marks indicating traffic on trails. From these small indications probable enemy locations and activity could be inferred and ordnance directed to these suspicious areas. Sometimes secondary explosions were the result.

Air Force OV-10 Operational Evaluation

From February 1968 through April 1969 157 OV-10As were delivered to the Air Force. Following the initial deployment of OV-10s the Air Force found that the airplane met the requirements established for a future FAC platform from a study made in 1966.[75,76] Armored crew protection, two engines, night/all-weather operability, and excellent maneuverability fulfilled much of the original requirement. Disadvantages in using the Bronco were also noted. These included the limited rear cockpit instrumentation, poor visibility with a Starlight Scope in the rear cockpit, and a poor cockpit environment hampered by high temperatures and high noise levels. Recommendations for improvement included installation of better rear cockpit instrumentation, the installation of an environmental control system, improved night visibility features from the cockpit, installation of self-sealing fuel tanks, incorporation of X–Band beacons to facilitate rendezvous, and the addition of a laser designator.[77] The OV-10 was found to be highly effective in an environment where air superiority was provided.[78]

On 28 July 1969 in a Project Corona Harvest interview, the assistant operations officer of 20th TASS observed that the OV-10 was infinitely superior to the O-2 and that it was a very good platform. The Bronco's hot cockpit caused aircrew fatigue and dehydration. It was also observed that the O-2 was preferred over the OV-10 for night work because of Bronco limited Starlight Scope utility and excessive instrument panel glare.[79]

5.3 Navy Service

In July 1965, the Navy began assembling a force of highly maneuverable, heavily armed coastal and river patrol boats to restrict enemy activity in the Mekong Delta. In 1966 they increased the deployment of SEAL teams to the Delta. In 1967, flying UH-1B Huey gunships on loan from the Army, Helicopter Attack (Light) Squadron Three, HAL-3, was established to provide dedicated quick-response air support.

By mid-1968, the Viet Cong and North Vietnamese Army still enjoyed virtually uninhibited access to major sanctuaries and the intricate network of smaller inland canals and waterways. Tasked to carry out more aggressive operations, Commander Naval Forces Vietnam (COMNAVFORV) proposed the establishment of a shore-based fixed-wing attack squadron to

[75] CHECO Report, *OV-10 Operations in SEAsia*, 15 September 1969
[76] SEAOR, Improved FAC Aircraft, *Tactics and Techniques of Night Operations*, *1961-1970*, Office of Air Force History, March 1973
[77] SEAOR, Improved FAC Aircraft, *Tactics and Techniques of Night Operations*, *1961-1970*, Office of Air Force History, March 1973
[78] *Case Studies in the Development of Close Air Support*, Office of Air Force History
[79] Corona Harvest, Maj. O.D Robertson, DaNang, South Vietnam 28 July 1969

provide additional dedicated air support for the planned increased tempo of operations. The new squadron was designated VAL-4.

VAL-4

Light Attack Squadron Four, Call Sign "Black Pony ", Assigned to COMNAVFORV, April 1969 – March 1972, Binh Thuy and Vung Tau, South Vietnam

Light Attack Squadron Four was commissioned on 3 January 1969, at NAS North Island near San Diego, California. In October 1968, eighteen OV-10A Bronco aircraft were transferred to the squadron from the Marine Corps, with fourteen eventually deploying to Vietnam and four remaining with VS-41 at NAS North Island for training replacement pilots and support personnel.

The initial cadre of aircrew included a handful of attack pilots with A-1 and A-4 backgrounds. The rest were S-2 pilots from decommissioned antisubmarine and airborne early warning squadrons who, though fleet experienced, had no experience in the attack role.[80] The aircraft began arriving in October and transition flights began the first week of November 1968, ending the last week in February 1969. The planes were then preserved and shipped to Vietnam. On 24 March, the squadron left San Diego with 36

Figure 23: VAL-4 OV-10s Loaded With Zunis, Mk4 Gun Pod, and M60s

[80] Kit Lavelle, *Flying Black Ponies: the Navy's Close Air Support Squadron in Vietnam*, Naval Institute Press 2000.

officers and 110 enlisted men. Combat operations began on 19 April 1969.[81]

Figure 24: VAL-4 Fire Team Section Over Rung Sat / Long Tau Shipping Channel to Saigon

Initially the squadron was divided in half with Detachment Alpha operating seven aircraft from VNAF Binh Thuy with responsibility for central and southern IV Corps. Detachment Bravo operated seven aircraft out of AAF Vung Tau, covering northern IV Corps along the Vam Co Tay /Vam Co Dong rivers in *Operation Giant Slingshot* and the Long Tau Shipping Channel transiting forty-five miles from the South China Sea to Saigon. In July 1970, Det. Bravo was disestablished and the squadron was consolidated at Binh Thuy. [82]

The VAL-4 tactical approach was an amalgam of Navy and Marine close air support doctrine, HAL-3 lessons-learned deploying the Huey gunships in the riverine environment, and feedback from patrol boat (PBR) crews and SEALs. Every pilot spent time on patrol with the PBRs, some took part in SEAL operations, and a number of SEALs and PBR sailors flew in the Black Pony back seats.

The Black Ponies departed Vietnam nearly three years to the day after their arrival in-country and

[81] Charlie Sapp 2015

[82] Kit Lavelle, *Flying Black Ponies: the Navy's Close Air Support Squadron in Vietnam*, Naval Institute Press 2000

the squadron was disestablished 10 April 1972. In all, approximately 145 officer and 530 enlisted personnel served in the squadron. During that time, they flew nearly 22,000 combat sorties while losing seven aircraft, with six pilots and one AO KIA and eight pilots and one AO WIA.[83]

Navy Operational Use

The VAL-4 mission was pure attack, most of it close air support of troops in contact and interdiction of enemy personnel and equipment. The rules of engagement allowed the squadron to operate autonomously without FAC control as long as weapons were limited to forward firing weapons such as guns and rockets. Missions could be flown in support of U.S. Navy and Vietnamese forces within one kilometer of a navigable waterway. However, as the word spread about the VAL-4 Bronco's responsiveness, loiter time and ordnance load, the inevitable mission creep occurred and the Black Ponies gradually found themselves supporting anyone who needed assistance irrespective of proximity to water. By late 1970 most U.S. naval forces had been withdrawn from the Delta and the preponderance of missions from then on were flown in support of Vietnamese army and naval forces.[84]

The back seats were initially manned by pilots who had just completed multi-engine flight training. Though they lacked any fleet operating experience and received scant training prior to deployment, all were checked out in the aircraft and began flying front seat missions soon after arriving in country.

Figure 25: VAL-4 Pilots' Favorite Ordnance Load; Twenty Zunis.

[83] Bob Peetz 2015

[84] Kit Lavelle, *Flying Black Ponies: the Navy's Close Air Support Squadron in Vietnam*, Naval Institute Press, 2000

Favored weapons were Zuni 5 inch rockets and the Mk4 20mm gun pod, augmented by sponson-mounted M60 machine guns, SUU-11 minigun pod, 2.75 inch rockets, and paraflares for night illumination. The favorite configuration for most VAL-4 pilots was twenty Zunis, four 4-shot LAU-10 pods hung under the sponsons and a 2-shot LAU-33 pod on the Sidewinder pylon station under each wing. In 1970 alone, the squadron expended 35,824 Zunis.[85] In late 1971, in a departure from the "only-forward-firing-ordnance" rule, the squadron was supplied with CBU-55 FAE to clear areas of booby traps, mines and enemy personnel. More than 700 CBU-55s were delivered on enemy targets over a six-month period. [86]

The standard mission was comprised of a two-plane Light Attack Fire Team. The front seat pilot focused on flying the aircraft and delivering the ordnance. The back seat pilot's duties included communication, navigation and assisting the pilot in maintaining situational awareness over the target, similar to those of the Marine AO described earlier. VAL-4 crews were neither trained nor authorized to control third party airstrikes or artillery so missions where naval gunfire or artillery were employed on targets required the expertise of a Marine AO in the back seat.

There were two basic mission types, the scheduled random patrol and the scramble alert. The scheduled patrols were two-hour missions flown both day and night and were designed to have a fire team airborne during times and near locations of recent enemy activity or where allied units were active. Two and occasionally three of these missions were scheduled each day. The scramble alert provided a dedicated fire team available to be launched quickly to support units in extremis. Aircraft could be airborne within 10 minutes and on their way to anyplace in the Delta. Pilots were assigned scramble duty every third or fourth day. Other missions were the single-plane patrol of the Rung Sat Special Zone carrying an AO, and fire teams assigned to cover special operations and conventional troop insertions. However the large majority of missions flown was of the two basic types. In 1971, two Marine YOV-10D NOGS aircraft, operating out of Binh Thuy, worked for a time quite successfully with the squadron. VAL-4 also teamed successfully with U.S. Army OV-1 Mohawks in night sensor/shooter teams.

Navy OV-10 Crew Observations

Those who flew and maintained the Bronco for the Navy held it in high regard, as did the troops on the ground and headquarters staff. It was appreciated for its maneuverability, visibility, and ordnance-carrying capability as well as its reliability. The OV-10 was a perfect addition to the PBR/HAL-3/SEAL team, bridging the performance gap between helicopters and jets. It was an excellent fit for the Vietnam riverine environment.

As other users have noted, however, it was hot in the cockpit and with a full load of ordnance the aircraft was grossly underpowered. Furthermore, as a one of a kind squadron isolated in the middle of the Delta, there were frequent supply issues, overcome by talented dedicated maintenance and supply personnel with some assistance from friendly Marines at Marble Mountain.

[85] Command History for Light Attack Squadron FOUR (1 Jan 1970– 31 Dec 1970)

[86] Command History for Light Attack Squadron FOUR (1 Jan 1971 – 10 April 1972)

6. OV-10 Changes during 1968-1975

6.1 Armament Changes

During the Vietnam War various changes were made to add armament capability to the OV-10 following its initial delivery. Among these additions are the 20mm GPU-2 gun pod, acoustic and seismic sensors, the CBU-55/B Cluster Bomb Unit (CBU), and the recoilless rifle.

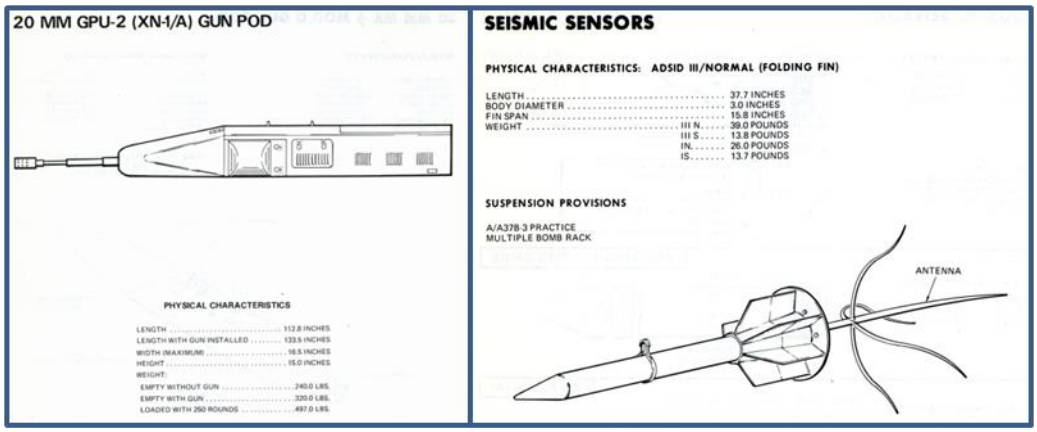


Figure 26: 20mm Gun Pod and ADSIDs

20mm Gun Pod: The 20mm GPU-2 Gun Pod was a product of Naval Weapons Center (NWC) China Lake development led by K.P. Rice. The gun was sourced from the A-4 Skyhawk and required an air bottle installation for gun charging since the OV-10 had no pneumatic system. It was an effective system but prone to jamming if firing was stopped after 2-3 rounds. The GPU-2 gun pod was first used in Vietnam by VMO-2 in February 1970 and is shown in Figure 26.[87]

ADSIDS: Air delivered sensors or ADSIDs were deployed by both Air Force and Marine Corps OV-10s in support of programs such as Igloo White that spread sensors along the Ho Chi Minh Trail to detect truck traffic and other movement. Some Air Force and Marine Corps OV-10s were equipped with portable sensor monitoring equipment that worked as designed but were limited by several factors making their use impractical.[88] ADSIDs are shown in Figures 16 and 26. Some Marine Corps OV-10 aircrews experienced some difficulty in getting them to separate reliably from the aircraft. ADSIDs required specific delivery parameters, ideally at 150 knots, straight and level at 500' AGL. If the majority of the sensor string wasn't laid down in one pass, additional runs vastly increased the chances of becoming a target for ground fire.[89]

CBU-55: The CBU-55, shown in Figures 15 and 27, was another product of NWC China Lake. It was a fuel air explosive that was designed to deploy three parachute-retarded bombs when

[87] Charles Burin 2015

[88] Bernard C. Nalty, *The War Against Trucks, Aerial Interdiction in Southern Laos 1968-1972*, Air Force History and Museums Program, Washington D.C.2005

[89] Gordon Evans 2015

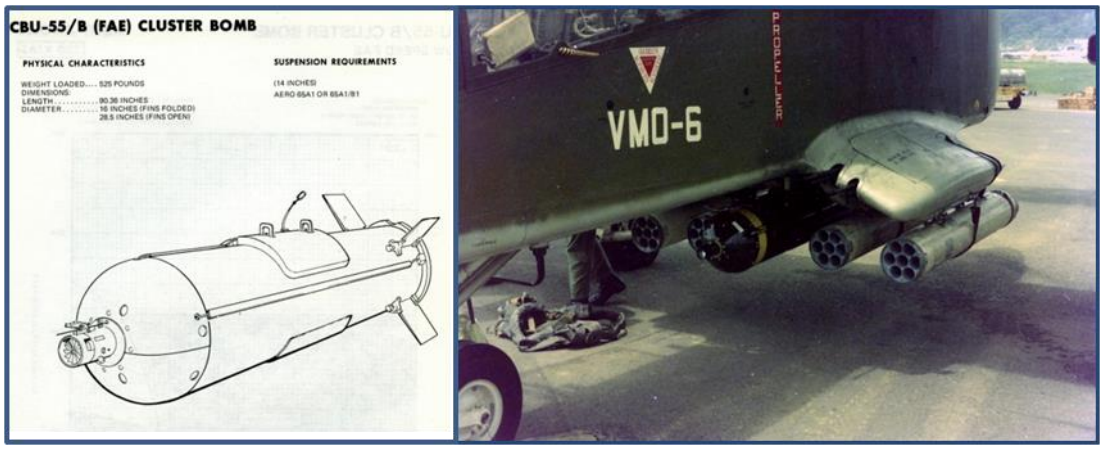


Figure 27: CBU-55 Fuel Air Explosive

specifically designed for use on a slow moving delivery aircraft. The purpose of the weapon was to create an over pressure that would clear a potential helicopter landing zone of pressure sensitive mines. The weapon was available for use by Marine Corps and Navy OV-10 squadrons.

First use of CBU-55s by the Marine Corps began in November 1970. It was estimated that the resulting blast was equivalent to a 2000 pound conventional bomb. Initial use was to clear helicopter landing zones and booby trapped areas and it was found to be useful for crushing bunkers, collapsing tunnels, as well as clearing foliage.[90]

106mm Recoilless Rifle: The recoilless rifle installation on the OV-10 was an influence from the Bennett and Rice L^2VMA paper that used a 106mm recoilless rifle as the main armament. It was one of the reasons twin booms with a high tail was specified for L^2VMA and the OV-10 used that configuration. Static tests at NWC China Lake were conducted and minor damage was noted to the empennage. Tests were also conducted with an OV-10 equipped with a recoilless rifle suspended from a crane. Aircraft damage was not likely to happen in flight test but the installation never reached that stage and was never fielded. [91] The recoilless rifle concept and static test set up are shown in Figure 28.

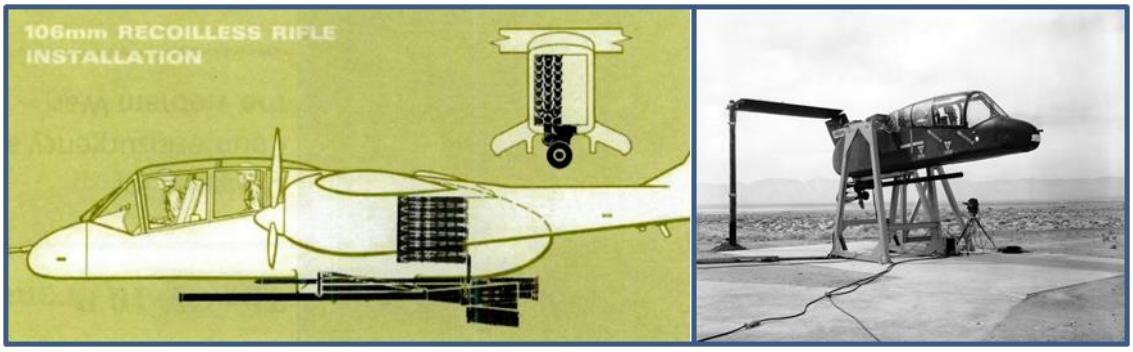


Figure 28: Proposed Recoilless Rifle Installation and Static Test Rig

[90] Graham A Cosmas, Lt Col Terrance P Murray *U.S. Marines In Vietnam 1970-1971*, History and Museums Division, USMC, Washington D.C., 1986

[91] W.H. Beckett, K.P. Rice, M.E. King. *OV-10 Story, Innovation vs the "System"*, unpublished OBA Version (annotated by K.P. Rice), undated

6.2 PAVE NAIL

The PAVE NAIL system was a significant modification to OV-10A capability deployed by 23rd TASS, the Nail FACS. By 1970 it was apparent that with the introduction of laser guided munitions there was a need for a forward air controller capability that could detect targets at night and guide laser guided munitions. The system was originally envisioned was a night target detection system for the O-2 aircraft called PAVE SPOT. Emphasis shifted to the OV-10 when it was determined that the O-2 was being withdrawn from Southeast Asia. The operational need was expressed in the Combat Required Operational Capability (CROC) 25-70. CROC 25-70 called for "an OV-10 night visual reconnaissance system that would include the capability to search for, acquire, track, and designate targets for delivery of laser guided bombs by loran equipped strike aircraft."[92] The nickname PAVE NAIL identified the system as associated with the overall PAVE WAY guided munitions program and the 23rd TASS at Nakhon Phanom as the operator using the call sign Nail. A two man aircrew concept was chosen based on the aircrew workload.

Figure 29: PAVE NAIL Equipped OV-10A

[92] Darrel Whitcomb, *PAVE NAIL: There at the Beginning of the Precision Weapons Revolution,* Air Power History, Spring 2011

The PAVE NAIL OV-10A system consisted of the PAVE SPOT pod which housed a gyro-stabilized first generation light intensification tube and a laser for laser ranging and guiding laser guided bombs. The aircraft control stick and rudder pedals were removed from the rear cockpit and a vertical optical column was installed upward through a hole in the floor of the aircraft and bolted in place. Control was through an inertial hand controller. The system could be rotated 360 degrees in azimuth and 0 to 90 degrees in elevation. Precision navigation was through an IT&T AN/ARN-92 loran C/D precision navigation system. The AN/ARN-92 Computer was modified to resolve the location of an object lased by the PAVE SPOT system to an accuracy of 20 to 60 feet using the input from the PAVE SPOT pod and the A-24G Reference Gyro. Included in the PAVE NAIL System was an SST -181 X-band beacon installed for use with the Combat Skyspot system and the AC-130 gunship. Two 100 gallon former A-37 Dragonfly drop tanks were installed on OV-10 wing pylons to make up for the removal of the centerline fuel tank. The capability to carry four M60 7.62mm machine guns, rocket pods, flare pods, and ground markers mounted on the OV-10 sponsons was retained.

The original operational concept was for the OV-10crew to detect and acquire a target using the PAVE NAIL system to relay the target's loran coordinates, height above sea level, and the desired run in heading for the target to an F-4 AN/ARN-92 equipped PAVE PHANTOM carrying laser guided munitions. With the F-4 PAVE PHANTOM at 15,000 feet above ground level a laser guided 2000 pound bomb would take about 37 seconds from release to impact. As the AN/ARN-92 equipped F-4 came inbound to the target on the desired attack heading the OV-10 PAVE NAIL Weapons System Officer (WSO) would begin to laser the target and the OV-10 pilot would begin to maneuver around the bomb fall line while keeping the target in view of the sensor using the PAVE SPOT pointing angles displayed in the front cockpit.

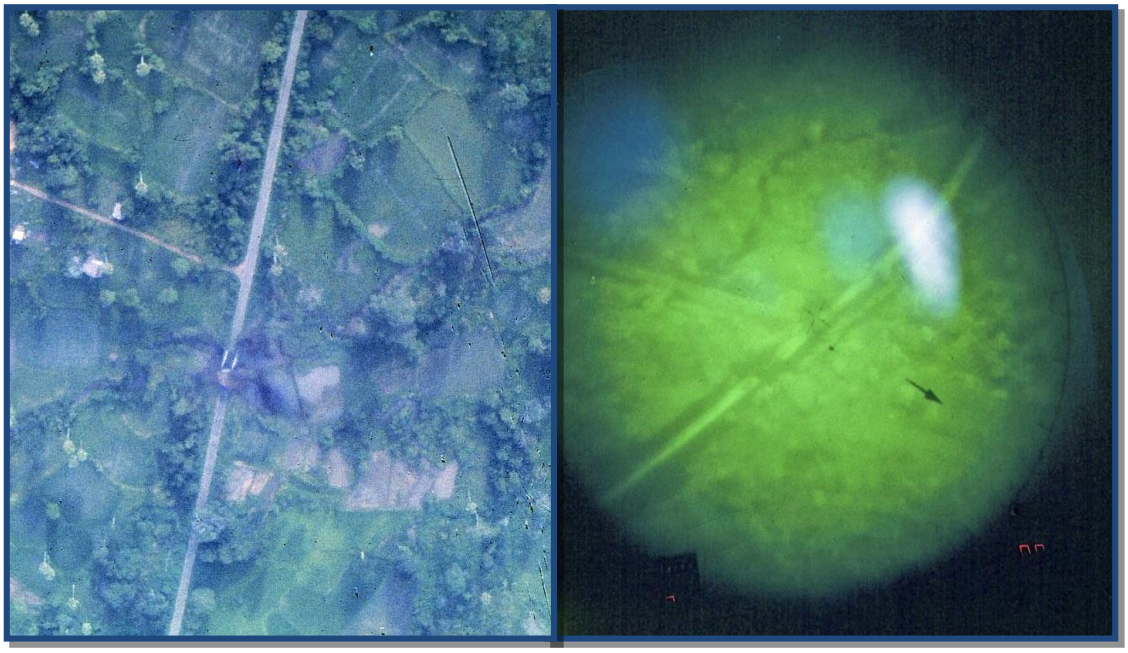


Figure 30: Bridge In Daylight and At Night With PAVE NAIL Scope

PAVE NAIL was initially evaluated using experienced pilots from the 23rd TASS and EB-66 operators who were re-designated as OV-10 PAVE NAIL WSOs. Initial system issues were resolved by the dedicated contractor on-site support. The stress of a maintaining a serviceable one-of-a-kind system remained throughout the life of the program. Training began in July and the first successful weapon delivery was in mid-August. Nine bridges in Cambodia used by the North Vietnamese had been selected as targets for the combat evaluation. This determined that 79.5 percent of the 2000 pound Mark-84 laser guided bombs hit within 40 feet of the laser designated target.

As the combat evaluation objectives were met and the crews became proficient they began flying night missions into the Steel Tiger operating area in Laos. The initial concept of operations was to operate throughout Steel Tiger giving first priority to preplanned fragged targets. F-4D PAVE PHANTOM aircraft were on-call and launched when requested by PAVE NAIL crews who had quickly learned to interdict supply routes and destroy anti-aircraft guns. Mission planning resulted in target data bases containing vulnerable road points, anti-aircraft guns, and suspicious areas that might contain supply points. Included were caves along the base of Mu Gia Pass. Crews learned the geometry and laser placement to put a laser guided bomb deep inside a cave. This was followed by learning to use the OV-10 system with loran equipped F-4Ds for accurate applications of non-guided munitions.

Experimentation by the PAVE NAIL crews led to major changes in operational use of the system including search and rescue. It was determined that the strobe flash of aircrew rescue beacon was detectable by use of the OV-10 PAVE NAIL system. Night trials determined that the survival beacon could be located by the OV-10 crew to within 60 feet or less. During these trials procedures were developed where the PAVE NAIL equipped OV-10 could determine the location of the survivor using a strobe light with an infrared filter installed and then go pick up the HH-53 Jolly Green helicopter and guide it to a hover over the survivor. These tactical applications were to factor heavily in future search and rescue operations over the next year.

In September and October of 1971 a day capability was developed with system modifications. In the day mode the OV-10 PAVE NAIL crew could detect a target, mark it with a white phosphorus marking rocket, and then laser the target for an attack aircraft armed with laser guided munitions executing a dive delivery. The number of available attack aircraft was increasing with the Air Force and carrier-based Navy aircraft using modified MK-82 500 pound laser-guided bombs[93] and OV-10 PAVE NAIL aircraft were now available for both day and night operations. The increased operational tempo also meant increased aircraft losses and an additional role for the OV-10 PAVE NAIL precision location capability. The system was used to precisely locate survivors, direct placement of area denial munitions, kill anti-aircraft guns, and to use the Bronco's extensive communications equipment to relay information from the rescue scene to the command and control centers. Subsequently numerous downed aircrews in Cambodia and Laos were located and rescued using PAVE NAIL

[93] Rick Atchison 2015: PAVE NAIL aircrews on an exchange visit to the USS America were given an A-7E orientation

capabilities. Laser guided bomb operations in support of SAR missions were timed to allow one survivors at a time to move through areas containing North Vietnamese troops into a safer location for pickup. By the time pick up was made there was little to no enemy resistance.

The 1972 *Easter Offensive* resulted in heavy enemy pressure in South Vietnam Military Region I and Region II. As the offensive began a USAF EB-66, call sign *Bat21* was lost on 2 April leaving the navigator trapped behind North Vietnamese lines. The crew of a PAVE NAIL equipped OV-10 immediately responded, precisely located the survivor, and began participating in rescue attempts. Enemy armored units moved into the battle area and OV-10 PAVE NAIL crews used guided and unguided munitions against them. As the offensive progressed OV-10 PAVE NAIL aircraft were deployed to Da Nang AB and Pleiku AB, South Vietnam. Responding to the *Easter Offensive* in South Vietnam, the system was used to direct laser guided munitions in close air support.

In 1973, the 23rd TASS was directed to remove the PAVE NAIL equipment from the remaining aircraft. The time for a propeller driven FAC aircraft with a laser designator and a loran precision navigation system had come to an end. However, the proven need for these capabilities continue and are incorporated in many of our more modern weapons systems.[94,95]

6.3 Night Observation Gunship System (NOGS)

On 28 February 1970 the Commandant of the Marine Corps issued a requirements message that focused on the need for current OV-10 missions to be conducted at night including night sensor reconnaissance. A program to address this requirement was begun 1 May 1970 scoped for evaluation of two service systems. A schedule was developed that included system completion by 31 December 1970 to be followed by a 90 day stateside evaluation period at NWC China Lake, MCB Camp Pendleton, and NAS Patuxent River. The two aircraft with integrated systems would then be deployed to Southeast Asia for tactical evaluation. These two aircraft were YOV-10Ds, the prototype Night Observation Gunship System, or NOGS.[96]

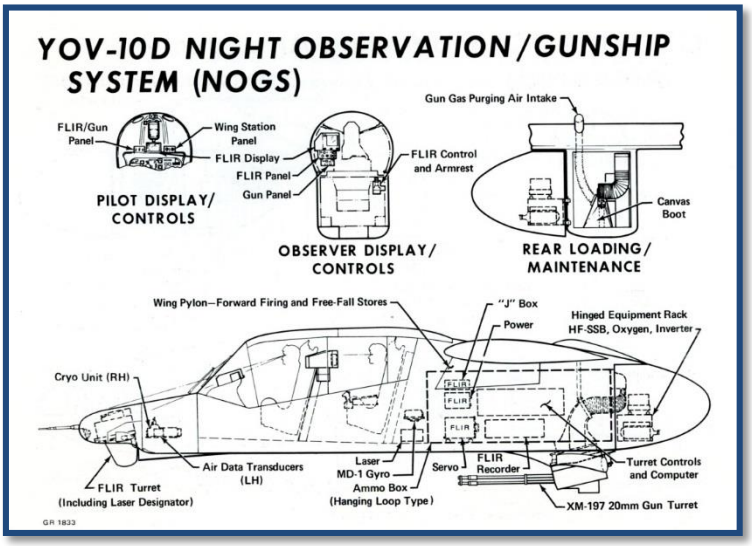


Figure 31: YOV-10D System Diagram

The NOGS system is a modified OV-10A with the addition of a Forward Looking Infrared Sensor or

[94] Darrel Whitcomb, *PAVE NAIL: There at the Beginning of the Precision Weapons Revolution,* Air Power History, Spring 2011

[95] Rick Atchison 2015

[96] Lt Col Bob W Farley, *NOGS,* Marine Corps Gazette, May 1973

FLIR with a laser designator, a 20mm gun turret installation, and two wing mounted external stores pylons.[97] The YOV-10D system installation is depicted in Figure 31. The FLIR was sourced from Hughes Aircraft and the XM197 three barrel gun turret from General Electric. The installations were designed by North American Rockwell and integrated on two existing OV-10As at NWC China Lake. Air frame modifications were required including a 30 inch extension of the nose to house the sensor installation, removal of the OV-10A gun sponsons, and fairing over the resultant opening. A cryogenic unit was added in the forward nose wheel well to cool the FLIR. Additional avionics including a fire control system were installed in the cargo bay. Displays and controls were added to both cockpits. The modification added approximately 2,300 ponds to the basic weight of an OV-10A.[98] During testing it was determined that the YOV-10D was underpowered with the additional weight of installed systems. If the system were put into production it would require a power increase so performance could be sustained at even OV-10A levels. Following successful preliminary testing, the two YOV-10Ds were evaluated in Vietnam in combat.

NOGS Deployment

On 26 May 1971 the two YOV-10Ds arrived at Cam Ranh Bay to begin the NOGS combat evaluation. Since Marine Corps OV-10 squadrons in Vietnam were standing down from combat operations, the NOGS detachment was collocated with VAL-4 at Binh Thuy in the Mekong Delta Region. Missions were flown in III Corps and IV Corps where system operation proved to be satisfactory. Crews flying the YOV-10D were credited with enemy kills involving the destruction of a storage area, four sampans, and three bunkers. The evaluation was completed by late August and the YOV-10Ds were returned to the U.S.[99]

NOGS airplanes like the one shown in Figure 32 were operated in formations either with one or two VAL-4 OV-10A wingmen, or paired with the other YOV-10D on a mission called "Double D".[100] During testing at China Lake it had been determined that 150 knots airspeed and 3000' altitude were appropriate attack parameters. Experience first obtained at Camp Pendleton was verified in Vietnam where covering foliage required attack airspeed to be reduced to 120 knots and altitude to 2000'. The attack profiles investigated where overhead the target, abeam the target, and in a pylon turn around the target along with conventional 30 degree and 45 degree angle dives. Pylon turn was used approximately in 98 percent of engagements with airspeed maintained at 90 – 100 knots. With Black Pony wingmen it was unnecessary to mark the target beyond engaging it with 20mm gunfire. The burst of 20mm high explosive/incendiary rounds on the target provided a sufficient night aiming point.[101] Wing pylon mounted weapons evaluated included CBU-55s, the SUU-44 flare dispenser, and 2.75

[97] D.P Alexander. Final *Technical Summary Report for YOV-10D Night Observation Gunship (NOGS),* Columbus, Ohio 23 April 1971

[98] Col Eugene L. Hollis Jr. USAF, Director Special Operations and Combat Support, YOV-*10D Evaluation Final Report*, Eglin AFB, Florida, July 1972

[99] *U.S. Marines In Vietnam 1970-1971*, History and Museums Division, USMC, Washington D.C., 1986

[100] James Dearborn 2015

[101] Lt Col Bob W Farley, , *NOGS,* Marine Corps Gazette, May 1973

inch rockets in LAU-68 seven shot pods or LAU-69 nineteen shot pods.[102]

Air Force NOGS Evaluation

As an operator of the OV-10A, the Air Force expressed an interest in NOGS and conducted an evaluation at NWC China Lake. The final report of this evaluation noted that the system was reliable, effective, and suitable. Noted in the report were that all the deficiencies identified in the Navy/Marine Corps report as well as those in the Air Force report could be remedied in a production version. The report concluded that the YOV-10D provided a suitable platform for gunship development and that the system provided a flexible night attack capability at a low cost compared to other more sophisticated gunships in use in SEA.[103]

Figure 32: YOV-10D NOGS

[102] James Dearborn 2015

[103] Col Eugene L. Hollis Jr. USAF, Director Special Operations and Combat Support, YOV-*10D Evaluation Final Report*, Eglin AFB, Florida, July 1972

7. Conclusions

7.1 The OV-10 in the Vietnam War

This paper has asserted that the OV-10 Bronco was designed for counterinsurgency and the Vietnam War. This assertion is based on the facts, as described in the paper, that the airplane was conceived as one that would live with the troops involved in a counterinsurgency role and that the authors of the concept paper mentioned Southeast Asia as one potential area of conflict where the L^2VMA would be useful. The LARA/COIN program that resulted in fielding the OV-10 was the combination of L^2VMA that had been transformed into LARA with the rising interest within the DOD in counterinsurgency. This happened in the early 1960s when U.S. involvement in Vietnam and South East Asia was growing. The Marine Corps needed the airplane to replace the O-1 and to create a new capability for such needs as armed reconnaissance and helicopter escort. The Air Force needed a replacement for the O-1 and the interim O-2 in the FAC role, both of these needs being for the combat arena in Vietnam. Initial orders were placed in 1965 and deliveries were concluded for U.S. forces in 1969, well within the time frame of the conduct of the Vietnam War. For these reasons, it may be concluded that the OV-10 met a specific need for a counterinsurgency weapon system that was fully deployed in Vietnam. Of the three services that operated the airplane, the Navy probably came closest to employing the OV-10 in a pure counterinsurgency role in its riverine operations. All three services were involved in at least a portion of their mission in Southeast Asia with counterinsurgency. The Bronco is still universally identified as THE U.S. military counterinsurgency airplane. It was successfully utilized in the Vietnam War to conduct the missions it was designed to do.

7.2 The OV-10 Post-Vietnam

Following the Vietnam War, the OV-10 found use by U.S. and foreign militaries and in civilian roles. These operations will be examined to see how the OV-10 mission changed and how it stayed the same.

Marine Corps OV-10 Use Following Vietnam

The Marine Corps continued to deploy the OV-10A in VMO squadrons. The YOV-10D NOGS after several years of development was deployed operationally as the OV-10D or Night Observation System (NOS) with deletion of the 20mm cannon and incorporation of more powerful engines. The OV-10A and OV-10D were the last U.S. Broncos in combat deployed in Desert Storm by VMO-1 and VMO-2. In addition to Desert Storm, OV-10s of VMO-1 and VMO-4, a reserve squadron based in Atlanta, were used to assist the Drug Enforcement Agency (DEA) in interdicting drug smuggling operations; a different sort of counterinsurgency. Soon after returning to the States the remaining VMO squadrons were disbanded and the OV-10 removed from Marine Corps service in 1994.

Figure 33: VMO-1 OV-10D at Camp Pendleton, 1993

Air Force OV-10 Use Following Vietnam

The Air Force continued to fly OV-10s until 1991. Notably Air Force OV-10s were deployed in Europe and contributed to forces there fighting the cold war. The last Air Force OV-10 used in combat was at the end of the Vietnam War Era over Koh Tang Island. The PAVE NAIL system was not deployed beyond Southeast Asia but represented the initial use of a bomb directing methodology and capability that is now commonplace.

Navy OV-10 Use Following Vietnam

The Navy returned their OV-10s the Marine Corps after VAL-4 was decommissioned in 1972. It should be noted that all the former VAL-4 airplanes were found to have cracked wing spars as a result of combining high G pullouts with twin Zuni pods on each wing pylon.[104] The Navy did continue to operate single OV-10As; one each at Navy test pilot school at NAS Patuxent River, Maryland, and at NWC China Lake, California. These airplanes were used for years in test pilot training and weapons development until the airplane was removed from U.S. service. The OV-10 at China Lake was one of two OV-10As with factory air conditioning; a feature appreciated at China Lake for test avionics temperature control and not for crew comfort. However, the Navy is currently operating a pair of OV-10Gs in Afghanistan continuing several years of evaluation in support of Special Operations Forces (SOF). The OV-10G is an updated former Marine Corps OV-10D. They are known as the "Black Ponies".[105]

Other OV-10 Operators

FOREIGN OPERATORS: OV-10As have been operated by the militaries of Germany, Morocco, Venezuela, Columbia, Indonesia, Thailand, and The Philippines. These were either purchased new from North American Rockwell or transferred from U.S. surplus assets. Excluding Germany, several of these nations have used their Broncos in a counterinsurgency role. The last to use the airplane, the Philippine Air Force, is currently in 2015 operating OV-10As on counterinsurgency missions in their nation's southern islands. They are looking for suitable replacements as the airplane is becoming unsupportable.

DOMESTIC OPERATORS: The U.S. has found several non-military uses for OV-10s and some are described below. The Department of State (DOS) operated a defoliation program in Columbia to attempt to eradicate coca plants and interdict a major source of cocaine. The airplanes they used were all former Marine Corps OV-10Ds with the mission equipment removed and an herbicide tank installed in the cargo bay along with spray bars under the wings. They also had additional armor plate added to the sides of the cockpit in recognition of the danger in flying low over coca fields. This

Figure 34: OV-10 Mosquito Sprayer

program was terminated in 2008 and the airplanes dispersed to museums and other

[104] Jim Hodgson, Ashby Shoop 2015

[105] Jim Hodgson 2015

destinations. One former coca sprayers was modified foe use by the county of Beaufort, SC as a mosquito eradication sprayer.[106]

NASA and the Bureau of Land Management also have had small fleets of former U.S. military OV-10A airplanes. NASA conducted several test programs in aerodynamics with their OV-10s. BLM used it's airplanes from 1993 to 1997 as fire fighting command and control aircraft. Two of the former BLM airplanes are in the OBA collection in Fort Worth, Texas. One, 155426, is a former USMC Vietnam vereran assigned to VMO-2 and the other, 68-03825 is a USAF Vietnam war veteran assigned to the 23rd TASS. Both are shown in Figure 36 with 825 restored as it appeared in Vietnam and 426 under going restoration in VMO-2 Desert Storm colors.

The largest current operator of OV-10s is the California Department of Forestry or CalFire. They fly a de-militarized OV-10A for lookout and command and control of firefighting assets.

Figure 35: CalFire OV-10A

These airplanes are also close to retirement having approached the limit of useful life.

7.3 In Summary

The OV-10 Bronco was used by the U.S. military with great mission success in Vietnam, in peacetime, and to a lesser extent in other wars. Other nations have also successfully employed the airplane in counterinsurgency operations. Civilian government agencies have used the airplane for roles and missions never conceived when the airplane was initially designed and built. But an examination of all the uses discloses a common thread. This airplane designed and delivered during the Vietnam era has for all its life been flown on a primary mission: *counterinsurgency*, whether the battle is against the Vietcong, coca plants, forest fires or mosquitoes.

Figure 36: OBA OV-10As On Display

[106] John Gumbel, Charles Burin 2015

Appendix A:
OV-10 Aircrew Losses, 1968-1975*

DATE	GRADE, NAME, AND SERVICE	LOCATION
25 July 1968	1/Lt Michael R. Hendrickson, USMC	Quang Nam Province, South Vietnam
25 July 1968	Capt Alfred L. Tripp. USMC	Quang Nam Province, South Vietnam
22 October 1968	1/Lt Rodney R. Chastant, USMC	Quang Nam Province, South Vietnam
22 October 1968	Capt Eugene W. Kimmel, USMC	Quang Nam Province, South Vietnam
3 December 1968	1/Lt Robert A. Carney, USMC	Quang Nam Province, South Vietnam
3 December 1968	1/Lt Robert L. Norton, USMC	Quang Nam Province, South Vietnam
13 December 1968	Capt Bruce B. Greene, USAF	Hau Nghia Province, South Vietnam
13 December 1968	Capt Charles F. Griffin, USAF	Hau Nghia Province, South Vietnam
30 January 1969	Capt Remi H. Greeff, USAF	Gia Dinh Province, South Vietnam
23 May 1969	Lt Peter F. Russell, USN	Kien Giang Province, South Vietnam
12 July 1969	Lt Aubrey G. Martin, USN	An Giang Province, South Vietnam
12 July 1969	Lt (jg) Roy D. Sikkink, USN	An Giang Province, South Vietnam
22 July 1969	1/Lt Roland C. Hamilton, USMC	Quang Nam Province, South Vietnam
29 August 1969	1/Lt Richard D. Krupa, USMC	Quang Tri Province, South Vietnam
29 August 1969	Capt Jack E. Schober, USMC	Quang Tri Province, South Vietnam
19 October 1969	Lt Col Frank H. Briggs, USAF	Bien Hoa Province, South Vietnam
19 October 1969	Capt James C. Woods, USAF	Bien Hoa Province, South Vietnam
4 November 1969	Maj Henry Coates Jr, USAF	Quang Ngai Province, South Vietnam
4 November 1969	Capt Charles L. Karr, USAF	Quang Ngai Province, South Vietnam
16 November 1969	Maj Philippe B. Fales, USAF	Tay Ninh Province, South Vietnam

DATE	GRADE, NAME, AND SERVICE	LOCATION
20 December 1969	Capt Carl E. Long, USMC	Phuoc Tuy Province, South Vietnam
20 December 1969	Lt (jg) Joel A. Sandberg, USN	Phuoc Tuy Province, South Vietnam
26 December 1969	Maj David L. Knott, USAF	Binh Long Province, South Vietnam
13 March 1970	Capt Frank Adams, USMC	Quang Nam Province, South Vietnam**
21 April 1970	Maj Eugene L. Wheeler, USMC	Quang Nam Province, South Vietnam
29 April 1970	Capt Wendell L. Brown, USAF	Hau Nghia Province, South Vietnam
29 April 1970	1/Lt Jose H. Ortiz, USAF	Hau Nghia Province, South Vietnam
7 June 1970	Lt Cdr Jere A. Barton, USN	Dinh Tuong Province, South Vietnam
30 June 1970	Capt William S. Sanders, USAF	Laos
3 July 1970	Capt William A. Justice, USAF	Cambodia
24 July 1970	1/Lt James M. Butler, USAF	Knotum Province, South Vietnam
13 August 1970	Capt John P. Powell, USAF	Quang Tri Province, South Vietnam
30 August 1970	MSgt Charles H. Gray, USA	Quang Nam Province, South Vietnam
30 August 1970	Capt Michael J. McGerty, USAF	Quang Nam Province, South Vietnam
17 September 1970	1/Lt Jerry Bevan, USAF	Pleiku Province, South Vietnam
11 October 1970	Capt Robert W. Brunson, USAF	Cambodia
18 December 1970	Maj James P. Allenberg, USAF	Chu Lai, South Vietnam**
20 December 1970	Capt James L. Smith, USAF	Laos
28 December 1970	SSgt Roger L. Teeter, USA	Laos
28 January 1971	Maj Harold B. Lineberger, USAF	Cambodia
24 March 1971	1/Lt Ron Yale, USMC	South China Sea
21 April 1971	Maj Herbert Miller, USAF	Quang Tri Province, South Vietnam
21 April 1971	Maj William E. Wood, USAF	Quang Tri Province, South Vietnam

DATE	GRADE, NAME, AND SERVICE	LOCATION
28 April 1971	CWO-2 Gerald L. Seybold, USMC	Quang Nam Province, South Vietnam
28 April 1971	1/Lt David W. Windsor, USMC	Quang Nam Province, South Vietnam
6 July 1971	Capt Donald G. Carr, USA	Laos
6 July 1971	1/Lt Daniel W. Thomas, USAF	Laos
12 August 1971	1/Lt John M. Rydlewicz, USAF	Binh Tuy Province, South Vietnam
24 December 1971	1/Lt William R. Finn, USAF	Laos
24 December 1971	1/Lt Timothy M. Tucker, USAF	Laos
9 February 1972	Lt Robert E. Lutz, USN	Kien Giang Province, South Vietnam
14 March 1972	1/Lt Arthur H. Hardy, USAF	Laos
7 April 1972	1/Lt Larry Potts, USMC	Quang Tri Province, South Vietnam
7 April 1972	1/Lt Bruce C. Walker, USAF	Quang Tri Province, South Vietnam
29 June 1972	Capt Steve Bennett, USAF	MR1, South Vietnam
26 September 1972	1/ Lt Vincent C. Anderson, USAF	Vinh Long Province, South Vietnam
6 October 1972	CWO Bruce E. Boltze, USMC	MR1, South Vietnam
6 October 1972	Lt Col Carl O. McCormick, USAF	MR1, South Vietnam
19 December 1972	Capt Francis X. Egan, USAF	Quang Nam Province, South Vietnam
27 January 1973	Capt George W. Morris, USAF	Quang Tri Province, South Vietnam
27 January 1973	1/Lt Mark A. Peterson, USAF	Quang Tri Province, South Vietnam
7 April 1973	1/Lt Joe Gambino Jr, USAF	Cambodia
5 June 1973	1/Lt Richard T. Gray, USAF	Cambodia

* Data from Chris Hobson*, Vietnam Air Losses*, Midland Publishing, 25 February 2002

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Charlie Sapp
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OV-10A Pilot, Vietnam Veteran

Jim Hodgson, USMC — VMO-2 OV-10A Pilot

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Bob Peetz, USN VAL-4 OV-10A Maintainer, Vietnam Veteran

Ken Semmler, RAAF 19th TASS OV-10A Pilot, Vietnam Veteran

Bob Whaley, USMC VMO-6 “Seaworthy Whiskey” OV-10A and UH-1E Pilot, Former CO, Vietnam Veteran

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Appendix D:
Abbreviations, Acronyms, and Terms

I Corps:	"Eye" Corps, or Military Region One (MR1), the northern most region in South Vietnam, adjacent to the Demilitarized Zone, or DMZ.
III Corps:	"Three" Corps, or Military Region 3 (MR3), the region that includes Saigon
IV Corps:	"Four" Corps, or Military Region 4, the southernmost region in South Vietnam, includes the Mekong Delta
III MAF:	3rd Marine Amphibious Force, in Vietnam two infantry divisions and an air wing plus supporting units
A-1:	Douglas "Skyraider", piston powered attack aircraft, Marine and Navy, later Air Force
A-37:	Cessna "Dragonfly" Air Force jet attack aircraft derived from the T-37 trainer
A-4:	Douglas "Skyhawk", attack jet flown by Marine Corps and Navy
A-6:	Grumman "Prowler" attack jet flown by Marine Corps and Navy
A-7:	Vought "Corsair II" attack jet flown by Air Force and Navy
AH-1G:	Bell "Cobra" armed attack helicopter flown by the U.S. Army and Marine Corps
AB:	Air Base
AC-130:	Lockheed "Hercules" cargo airplane modified for the Air Force as a gunship
ADSID:	Air Dropped Seismic Intrusion Device
AFB:	Air Force Base
ANGLICO:	Air Naval Gunfire Liaison Company, Marine Corps unit
AO:	Aerial Observer, Marine Corps designation
ARCLIGHT:	B-52 Strike in South Vietnam
ASEG:	All Service Evaluation Group
BLM:	Bureau of Land Management

BLT: Marine Battalion Landing Team

C-133: Douglas “Cargomaster” Air Force turboprop cargo airplane

C-141: Lockheed “Starlifter” Air Force jet cargo airplane

CAS: Close Air Support

CBU: Cluster Bomb Unit

CHECO: Contemporary Historical Evaluation of Current Events, USAF SEA historical documentation collection

Click: Kilometer

COIN: Counterinsurgency

Corona Harvest: USAF lessons-learned documentation from Vietnam

CS: Tear Gas

DASC: Direct Air Support Center

Dash 1: Air Force pilot’s flight manual

DDR&E: Department of Defense Research and Engineering

DEA: Drug Enforcement Agency

DOD: Department of Defense

DOS: Department of state

E&E: Escape and Evasion

EB-66 Douglas “Destroyer” Air Force jet bomber configured for electronic warfare

F-4: McDonnell “Phantom” jet fighter aircraft, operated in SEA by USAF, USMC, and USN

FAC: Forward Air Control

Frag: A fragmentary order, part of a upper level command order that is “fragmented” as it is passed to lower level units for execution

Fragged: Ordered by a higher level command, part of the daily operations order of a squadron

FOL: Forward Operating Location

G:	Acceleration equal to the force of gravity
GPU-2:	NWC China Lake-designed 20mm gun pod with 250 rounds of ammunition
Guard:	121.5 MHz VHF or 243.0 MHz UHF preset radio channels used for emergencies
H-21:	Piasecki Boeing Vertol twin rotor cargo helicopter flown by the Air Force and U.S. Army
HH-53:	Sikorski "Super Jolly Green Giant" helicopter, Air Force version of the CH-53 modified for search and rescue operations
H&MS:	Marine Headquarters and Maintenance Squadron, pronounced "hams"
HE:	High Explosive, a type of 2.75 inch rocket warhead
HML:	Marine Light Helicopter Squadron
HMM:	Marine Medium Helicopter Squadron
ILS:	Instrument Landing System
KIA:	Killed In Action
Knots or kts:	Nautical miles per hour, 15 percent greater than miles per hour
L^2VMA:	Light Light Marine Fixed Wing Attack
LARA:	Light Armed Reconnaissance Aircraft
LORAN:	Long Range Navigation, a low frequency system that using time measurements from several transmitters as a means of position location.
M60:	Light 7.62mm (30 caliber) machine gun carried by ground troops during the Vietnam War. The OV-10 was armed with four, two in each sponson.
Mk4 Gun Pod:	Hughes twin barrel 20mm gun pod with 750 rounds of ammunition
Mk45 Flare:	Air dropped paraflare with three minutes illumination duration
MAG:	Marine Air Group
MARDIV:	Marine Corps Division
MCALF:	Marine Corps Auxiliary Landing Field
MCAS:	Marine Corps Air Station
MCB:	Marine Corps Base

MOS: Military Occupational Specialty, A military member's specific job description

MR1: Military Region One, see I Corps

MR3: Military Region Three, see III Corps

MR4: Military Region Four, see IV Corps

NAS: Naval Air Station

NATOPS: Naval Air Training and Operating Procedures Standardization, Marine Corps and Navy pilot's manual

NOGS: Night Observation Gunship System

North American: North American Aviation (NAA), also North American Rockwell, the company that developed the OV-10 in their Columbus, Ohio facility, now part of The Boeing Company.

NOS: Night Observation System

NPE: Navy Preliminary Evaluation

NWC: Naval Weapons Center (China Lake)

O-1: Cessna "Birddog" USAF light aircraft, several variations. It was OE-1 in USMC service, L-19 in the Army before consolidation of designations in 1962.

O-2: Cessna "Super Skymaster" Air Force light aircraft

OBA: OV-10 Bronco Association, a Texas not-for-profit organization with a museum at Meacham International Airport in Fort Worth, TX http://www.fortworthaviationmuseum.com/home1.aspx

OV-1: Grumman "Mohawk" U.S. Army 2 seat twin turboprop combat airplane

OV-10 North American Aviation "Bronco" operated by USAF, USMC, and USN in Vietnam

OY-1: Stinson light military airplane first used in WWII

PBR: Navy Patrol Boat, River

POW: Prisoner Of War

RAAF: Royal Australian Air Force

RAG: Replacement Air Group, Navy

RFP: Request For Proposal

RNZAF: Royal New Zealand Air Force

ROE: Rules of Engagement

S-2: Intelligence section of a military unit

S-2: Grumman “Tracker”, Navy submarine hunting aircraft

SAR: Search and Rescue

SEA: Southeast Asia

SEAOR: Southeast Asia Operational Requirement, USAF

shp: Shaft Horsepower, the measure of a turboprop power output

SOF: Special Operations Forces

Starlight Scope: Vietnam-era low light vision aid

STOL: Short Takeoff and Landing

SUU-11 Minigun: Podded 7.62mm rotating six barrel Gatling-style gun

TACAN: Tactical Air Navigation

TAC (A): Tactical Air Control (Airborne)

TAD: Temporary Additional Duty, a naval service term

TAOR: Tactical Area of Responsibility

TASG: Air Force Tactical Air Support Group

TASS: Air Force Tactical Air Support Squadron

TBF/TBM: TBF Grumman “Avenger” Navy and Marine Torpedo Bomber later manufactured by GM as the TBM, used by USMC in WWII and Korea

VA: Navy Attack Squadron

VAL: Navy Light Attack Squadron

V_{NE}: Velocity Never Exceed, Maximum Airspeed Limit

UH-1B:	Bell “Huey” helicopter gunship variant operated by the U.S. Army and by the Navy in HAL-3
UH-1E:	Bell “Huey” helicopter gunship variant operated by USMC VMO squadrons
UHF:	Ultra High Frequency, OV-10 airplane to airplane or air traffic control communications
USAF:	United States Air Force
USMC:	United States Marine Corps
USN:	United States Navy
VHF/FM:	Very High Frequency/Frequency Modulation, radios for communication with ground troops or helicopters
VMO:	Marine Observation Squadron
VR:	Visual Reconnaissance
VS:	Navy Sea Control Squadron, during the period equipped with Grumman S-2s
WestPac:	Western Pacific, naval area of operations that included Vietnam
WIA:	Wounded in Action
WP:	White Phosphorous, or “Willy Pete”, usually a type of 2.75 inch rocket warhead used for marking targets
WSO:	Weapon System Operator
YOV-10:	North American Aviation “Bronco” prototype, both YOV-10A and YOV-10D
Zotting:	Illuminating a target or location with a laser designator
Zuni:	Five Inch High Velocity Air Launched Rocket

Appendix E:
Vietnam Era OV-10 Patches & Emblems

North American Rockwell

USMC and USN

USAF

USMC NOGS 1

USMC NOGS 2

Air Force

504th TASG

19th TASS

19th TASS

19th TASS

20th TASS

20th TASS

20th TASS

20th & 21st TASS

21stTASS

Rustic FAC

Rustic FAC

23rd TASS

23rd TASS

PAVE NAIL
Evaluation

23rd TASS

Marine Corps

MAG-11

H&MS-11

VMO-2

VMO-2

VMO-2

MAG-36

VMO-6

VMO-6

1st MARDIV AO

3d MARDIV AO

VMO-5

HML-267

NOGS

Navy

VAL-4

VAL-4

VAL-4

VAL-4

VS-41