JATO: The Early Days

By

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Early one morning in 1944 the crew of a Navy PBM-3C (C 86 or Charlie 86) delivered to the Coast Guard San Diego Air Station a liquid propellant rocket motor system to be used in some open sea seaplane landing and takeoff experiments. A navy contract had been let to research the infant JATO (Jet Assist Take Off) system's use in the open sea. The navy aircraft's crew were trained pioneers in the JATO systems, the copilot of many test flights was an officer, non-aviation chemical engineer and rocket fuel specialist.

The photo on the right is "Charlie 86" preparing to land from one of the early flights.

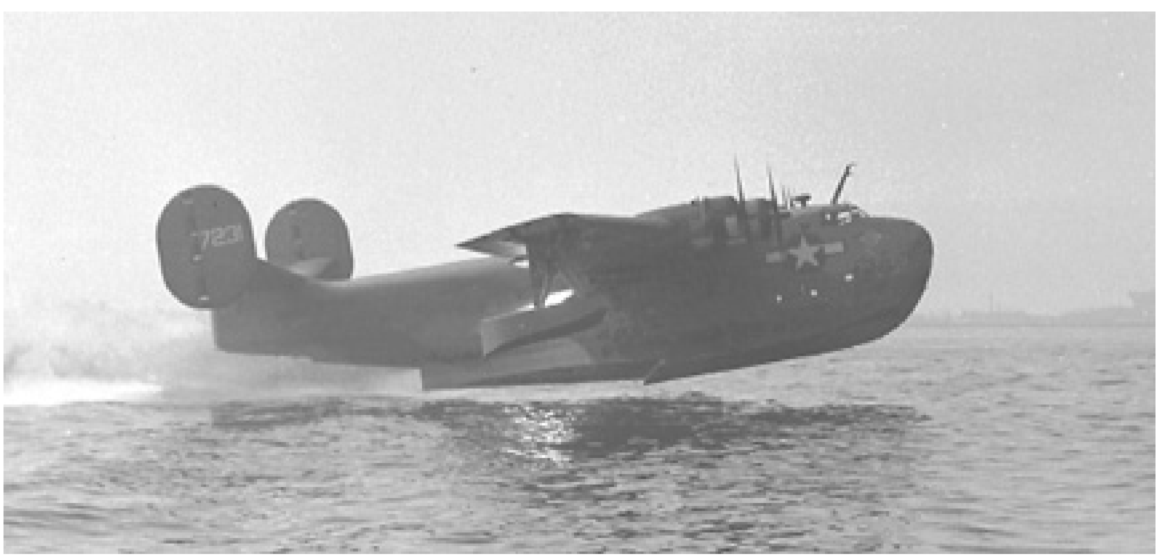
As delivered the entire rocket maintenance system was self-contained. Its large diesel provided workshop electrical power and through a series of compressors utilized the exhaust to generate an inert gas under high pressure. It was a highly specialized rocket motor plant for war use during an invasion.

The rocket motor GALCIT1400 ALDW (Guggenheim Aeronautical Laboratory California Institute of Technology 1400 pounds thrust Air Launched Droppable Water) fuel system used pressurized gas to drive the liquid fuels to a firing chamber through a gauged spray system. The self-igniting (hypergolic) system fuels were monoethylaniline and a mix of hydrosulfuric and red fuming nitric acid as oxidizers. No need for fuel pumps or ignition systems. Simple valves could turn the fuels on or off which was a huge benefit over solid fueled once-fired-all-fired systems. A similar type of liquid motors designed by Reaction Motors of New Jersey was being used in the highly classified Northrop flying wing which in 1944 became the first rocket propelled aircraft as it flew for over 10 minutes at Muroc Dry Lake.

I was a surprised when the plane captain said they were out of Annapolis where Dr. Robert Goddard had a laboratory developing rocket assist motors for the catapult of aircraft for short take off performance. Perhaps light surveillance planes flying from LSTs. Dr. Robert Goddard one of the most notable rocket scientists, earlier in Massachusetts belittled for his rocket experiments that included supporting science fiction writers, left his studies in Massachusetts for friendly Alamogordo, New Mexico. It was the move that set the tone for rapid rocket development in California and the Far West.

Captain Bob Workman, USCG (RET) a former Academy pistol champion when I was coach, visited me on a trip through the DC area and recounted some of his experiences as a pilot supporting various agencies involved in drug traffic control. I reflected that I had an experience with the Navy JATO development during WWII that probably never got into the annals of CDR MacDiarmid's off-shore landing program. As an old seaplane SAR pilot Captain Workman was more than interested. I cautioned him that my memory was good but I was not to be held to the exactness of flight logs, other witness accounts or written references!

To set the stage of why an AOC in CG aviation might be of value to the Navy in cutting edge technology or rocketry one only needs to know where growing hungry young adventurers best found their information; science fiction, of course.   Aviation was beginning to come into its own in the 1930's and I was hooked. The work of the Russians, Germans, British and American pioneers in rocket propulsion sprouted several club-like groups of authors, scientists and engineers writing science fiction. Investigating among other things the answer for more power to catapult aircraft something neglected by the trained aeronautical engineers of the times who fought inertia and gravity with larger, heavier, piston engines. To this Coast Guard ordnance man it was a dream come true, just to be near, to see the perfect nozzle exhaust, hear the roar so often spelled out in science fiction.



These two Navy photos shows a Navy PB2Y3 seaplane with the first liquid propellant engine being test-fired prior to an early heavy load test flight and then the second photo of the graceful, the beautiful lift from the water.

It all began much earlier with scientists and engineers at Caltech and a group that formed Aerojet Engineering Company, an R&D organization whose beginnings was with members of the American Rocket Society. They became a well established manufacturer of rocket motors by the time the Navy began testing them at CGAS San Diego. The company went on to become a most important part of the U S space race.

These original liquid fueled motors were used as extra engines for take-off and then dropped to reduce weight. Some bombers, such as the B-29, attempting to take off with full loads of fuel and bombs from short island runways with straining engines dangerously overheated on hot atolls, would be a natural place to attach two of these motors. As in the test pictured above a liquid motors were attached to hard points under the wings of a PB2Y3. Used during the take-off run they provided that much needed power to get air-borne, later to be dropped safely by parachute for recovery and re-use. If a takeoff was aborted they could be shut down.

A contract problem had developed as the naval air people waxed and waned about JATO rocket propulsion, threatening the contract and only providing Dr Goddard's laboratory in Annapolis one test crew to follow ideas of seaplane JATO missions. It was not part of the missile work in China Lake but derived support there. The Army Air Corps provided a chase plane, originally an A-20, later an A-26, rugged high speed bombers that were used for testing rocket modifications and new Aerojet designs.

JATO found a made to order requirement when the Coast Guard started a series of off shore tests to determine the safest and most effective method of open sea landings and takeoffs. During take off a seaplane experienced a series of potential damaging occurrences, the least of which was to achieve flyable speed before the engines were drowned. Propellers have been found to have their blades bent forward from rough water.

Rough water off shore landings and takeoffs by aircraft used in SAR experiments was not new. The British had an advanced Search and Rescue (SAR) organization with heightened experience simply because WWII was the airplane's war since 1939. One item in particular was the Lindholme Gear, a series of survival items attached by nylon cord when dropped by the bombing system's intervalometer would lay an up-wind line 1000 feet long, all floating and drifting down wind to the people in the water. The CGAS San Diego adopted a version converting to the USN type of dinghy and survival equipment. There were 5 elements, varying in weight that as a unit weighed more than 500 pounds.

Part of the assigned Coast Guard SAR effort became central to San Diego CGAS which was to research and advance or innovate the standard survival equipment, improve delivery systems to downed aviators, train parachute riggers and ordnancemen on survival in open sea landings, providing expert knowledge of handling, loading and dropping equipment as a crew member of the SAR rescue team. The station ordnance department teamed up with the parachute loft, a chief parachute rigger, Gus Olson, was indispensable for the proper designing, fitting and protection of droppable equipment.

Although rocketry was not a strong point in Commander MacDiarmid's aviation, he allowed the Ordnance Department a free hand to help the Navy crew. That became an unreal opportunity as without orders or supervision and chief of the department I was allowed to join and fly as a crew member on navy experimental systems, participate in and learn the operation of various rocket motors and become awash in the new science of rocket propulsion.

It was exciting watching pioneers, Navy, Aerojet, CalTech, make their mark and be asked to help them. Note my position in the middle of the below Aerojet picture of a mix of scientists and engineers from Aerojet on a visit to CGAS San Diego when they observed the different solid and liquid rocket motors then being tested with PBYs, PB2Y3s and PBMs.

USMC Captain Bill Gore, on my left, the test pilot for the JATO program, insisted that I pose with this august group.

A few days after the Navy's liquid experimental support unit and motors showed up, the test rig was in place overlooking the sailboat marina at the south west corner of the station. Fuel was delivered. This was no tank truck pulling up and some hose laid out. The barrels of fuel were in box cars that entered the side rails at Consolidated Aircraft Company, accompanied by several fire engines. Behind the train's closed and locked doors seeped smoke that not only had color but teeth, as the door showed signs of flaking! Stainless steel drums carefully sealed could not hold the combination of sulphuric, hydrochloric and red fuming nitric acid fumes. Stof N and O the Germans called it. Hypergolic systems.

The photo at left is from the Smithsonian exhibit, donated by Aerojet, of an engine that proved the concept. A beautifully fashioned machine showing the three spheres, firing chamber and nozzle, simple, effective, setting the standard for what became extra-terrestrial flights

The fuels allowed a simple motor design with few moving parts, a rocket motor that was inherently reliable. Pressurize the tanks of acid and aniline, squirt them to meet and automatically ignite in the firing chamber, "lift off." The rocket nozzle was the only truly complicated and cutting edge design, with the fuel being routed around the nozzle throat by metal tubing, to become a regenerative system. Actually the use of fuels traveling through pipes around the throat of the nozzle, cooling it while warming the fuel, was well known, maintaining that operating temperature so important to forming the perfect mathematical balance for exhaust velocity as well as preventing throat erosion. Even so, on takeoff it was a rip roaring static howling stinking toxic mess that during the wing attached motors aimed somewhat downward dug a continuous hole three feet deep each side of the airplane. That was not on the high mounted PB2Y3 as seen in the photo. On the modified PBM3C they were attached in the engine nacelle beaver tails, the seaplane had a nose high attitude prior to getting on the step, thus the nozzle stream dug the deep holes. Liquid JATO engines went forward.

At the beginning of the off shore landing trials, as CDR MacDiarmid took over from test pilot marine Bill Gore, the attached liquid motors, in every day operations presented too many field use problems. On one landing the right wing unit broke from one of its attachments presenting problems as the acids burned into the aluminum as well as prohibiting attachment problems. Not exactly what the mission called for.

Trial and error, photo and analysis of data, MacDiarmid's work had begun, a careful study of offshore landing technique under all circumstances, for which he was to earn the DFC. JATO experiments were not included in his program.

The test seaplane, a Navy PBM3C, was fully weaponized and combat ready, a bit different from the PBM5 we used for SAR work. North Island Naval Air Station put me through Air Combat Crew training as well as open sea hard hat diving and explosive handling for which I was grateful. Coming to aviation as a chief gunners mate left me a little short of where the other 'regular' airdales thought I belonged but this study earned me some support. Further navy training made it possible for me to continue with the Navy Test Team.

The GALCIT1400ALDW was packed up and trundled off to other work, notably the before mentioned Northrop flying wing for which the GALCIT1400 was fitted. Also of interest was its installation in a zero-launch P51 with the rocket motor in the tail. rumored as an answer to the Messerschmitt 163E. Superior performance but again the fuels created almost insurmountable problems. The Navy opted to go solid propellant for JATO.

On the left, the original unit as presented to the Smithsonian by Aerojet.

It was a joke among the navy test crew of how the solid JATO was manufactured given all the wartime restrictions in the use of critical metals and chemicals. The standard diameter pipe used as oil well casing was readily available, a steel, of sufficient strength for firing chamber pressure and of a nominal diameter to fit the 1000 pound thrust for 14 seconds, engineering requirement. A cap at one end, nozzle at the other, hole to accept the igniter, some thread making and pour a mixture of potassium-perchlorate and tar-like goop for propellant, voila, Jet Assist Take-Off. It is hard to remember all the trials for decent propellants that did not explode if not burning correctly but there were a few. The unit was probably called 14KS1000. It was generally known as "old smoky" as it generated a huge cloud of smoke if burning properly. It did produce the advertised thrust.

Probably a Navy photo circa 1945 that emphasizes the "old smoky" emission slang for the solid fueled JATO system. The above attachment to the hatch was the latest and most successful of several points to hang the motors.

People kid a lot today about duct tape, which is the universal item of choice for repair and or mend anything. So it was at Aerojet. The propellant poured into the casing was firm and acted nicely at cool temperatures, but tended to slump at warm or badly cracked in the cold elements of high altitudes. Handling, rattling loose fuel in shipment or stowage in an aircraft rendered the rocket motors unsafe, Burning of solid propellant is simple, ignite the face and burn uniformly of that face. The face presented is established as the proper pressure to provide the useful flow through the nozzle. Slump presents a greater face, quicker burn rate and higher pressure. Cracks allow multiple faces to burn simultaneously, leading to explosive forces in the firing chamber. Mixes with stabilizers helped but were not totally reliable. Finally a good R&D man made a mold, poured the propellant, then wrapped it with duct tape. Like a cigarette it now stayed in shape. The January 1986 CHALLENGER shuttle disaster is an example of what can happen when the propellant is not burned properly. The culprit, called a booster rocket, was really only a 'S' JATO.

Ordnance tests on the AS 1000 proved that any ammunition of .50 caliber or less, even if penetrating the casing, would not cause a high order explosion but there was an occasional detonation from 20 mm. All this was done by a hard working Aerojet group in Azusa, California, producing "quick and dirty" R&D that became excellent wartime equipment.

John Vukic was CDR MacDiarmid's off-shore test right hand man. Part may have been because CDR Mac was ornery enough to prove that a former Radioman 2/c AP (Aviation Pilot) was a better pilot than any of the good sized staff of officer pilots in the wardroom.

John, during the MacDiarmid program, then either a CAP (Chief Aviation Pilot) or LTJG had some leeway to order an aircraft out for experiment, as a result could and did satisfy his curiosity of the true efficacy of rocket motors by looking into just how much the solid JATO helped a PBY get out of the water. We had a Navy test PBY that had 4 JATO fittings rigged aft by the blisters and 4 forward just aft of the cockpit, a total of 8 (4 on each side). Tests had not proven where, on the fuselage the location of the bottles were most effective or if they might affect stability. Some Navy team experiments had just been completed timing first the rear set then next the forward set, but never all eight. It was awkward on the PBY because installation of the forward set of bottles had to be done on the ramp.

To Pilot Vukic more is better. Fine points of when to fire the units came into play except all eight at once was like adding another engine at full throttle, so to hell with where and when in the takeoff run but just two-block everything and trim out once clear of the water. On a quiet Sunday afternoon without the Navy about, I was in the starboard blister having rigged all eight units while on the ramp. Takeoff would be in the channel. Pilot instruction for takeoff was to trim 14 degrees up or what-ever the equivalent was on a particular machine. Point was, expect to leave the water at near stall but airspeed would gain rapidly, even in a nose up position.

Give it a try. From where I sat the results were astonishing. This was a PBY5A, amphibious with the landing gear noticeable from the blisters in a water takeoff. My position was such that when our plane lifted, there was no step, actually jumped from the water, the nose so high that I was looking at the horizon under the wheels, sustained long enough to get well clear by the time Pilot Vukic could adjust to a more normal flight. Vukic never said much but I know he was satisfied that thrust from the units really helped the thrust from the propellers. Estimated take off time about 3 seconds, about as good as the old Hall Boat!

A variety of tests went into different sea conditions, takeoff weight, handling, enough to prove the system for the seaplane short take off and heavy cargo needs.

The next big requirement of any significance was to check the use on the Navy JRMs, those large Martin Cargo seaplanes named the MARS that became the air supply logistic element between San Francisco, Hawaii and major Pacific islands. The *Caroline Mars*, a JRM-2, later broke the world record for passenger lift by carrying 269 men from NAS Alameda to NAS North Island, San Diego. They were large aircraft.

We were to test JATO on the Philippine MARS, the newest of the fleet of 5 operating in 1945. Six JATO were to be used. The biggest need was to get on the step, especially in calm waters. Often, to facilitate take off from NAS Alameda, California, with a load of approximately 32,000 pounds, high speed rescue craft would cross in front of the seaplane, not only assuring a path free of logger-heads and other dangerous obstacles but creating a rough surface to help the boat shaped hull to "break suction" as the old timers would say.

The emphasis upon size was demonstrated when the refueling trucks arrived on the morning of the trials. Carrying 1,500 gallons of fuel each over 10 trucks were eventually used. It was impressive but not nearly as much as the inside space when we finally went on board. The JATO had been installed earlier. Although Capt Gore usually flew JATO flights the Alameda crew were to take over this flight, mostly as observers and to furnish additional information. I was on the flight deck near the engineer's position, a fine place to observe cockpit activity during this history making flight.

The takeoff was without incident. A careful taxi to an open area in San Francisco Bay, turn into the wind, the engine full power created or pushing that huge hull to flying speed prompted the vibrations that shook the instrument panel enough to make the gauges hard to read. JATO was smooth, it was reported that takeoffs were reduced by up to half, equaling our experience with high altitude and very hot runway experience.

IN CLOSING

Rocket motor for aircraft quickly disappeared when jet engine development took off, providing a powerful and safe form of transportation. Only for special circumstances are JATO or RATO units used today, often for a spectacular display of short takeoff at air shows or on expeditions where the rockets provide a added safety.

Remember the saying, what goes around comes around? Imagine my surprise, in the 1980s, when as a consultant to companies building forest fire fighting systems into WWII aircraft, I saw the Philippine Mars majestically flying on a forest fire, a "scooper" similar to the PBY, where the aircraft settled in high speed taxi while scooping lake water for the internal tank system, to mix as retardant then drop upon a fire!

Navy photo of the actual JATO test from NAS Alameda.

Also, a year or so later, perhaps early 1946, BOAC, Britain's overseas air line, visited CDR MacDiarmid seeking information about the JATO and his experience with it. BOAC's new aircraft being ordered were heavier and needed longer runways, probably not to be found in India, Indo-China and the Middle East. At a round table discussion in the wardroom which I was honored to attend, the recommendation was to go with an extra engine. Balance between the difficult logistics with handling, storage and safe usage of JATO compared to the extra engine (for all safety as well as performance) looked like the way to go. Seaplanes would be gone from high use commercial traffic by the 1960s.

BOAC was not the only enterprise interested in JATO. Early one morning LT. Bob Gould asked me along for a trip to Culver City to meet with Howard Hughes, possibly something about our work with rockets and seaplanes. I had known and followed closely the controversy and stubborn go ahead Hughes had in order to build a flying LST. While early in the war stationed at 11th District Headquarters working with USCG Auxiliary people from Douglas and Lockheed the Long Beach aviation circles discussed the amazing activities in Culver City; a three-rudder airliner fast as a fighter, sealed fuselage with comfortable amount of oxygen; a twin R-4360 engined attack plane (AF 11) almost the size of a PBY; plus an all-wood seaplane larger than a football field!

It was hinted at and I could only assume that Hughes was thinking of using JATO for the his huge Hercules H-4 seaplane. Hughes privately owned 11,000 foot runway and huge hangars in Culver City was the only place capable of supporting the immense undertaking. When finished and ready to be moved to Long Beach harbor, the three major pieces, wings 150 feet long, fuselage over 200 feet, required considerable take down and reinstall along the travel route.

The cities from Hughes Airport to the Long Beach port facility refused to have a series of streets disrupted, electric and telephone lines down and possible long interruption of service. If Hughes, who had a short fuse for frustration, needed to get to the water, had an option, he could build a marine railway on his 11,000 foot dirt runway and with the use of JATO, catapult the finished seaplane and fly it out. I heard none of this from his staff but it seemed the only reason for my being there. Historical photographic records note that not only did the cities allow it to make it to the water, but later, in a taxi test Hughes, inadvertently (it had no government permission to fly) arose to 70 feet and flew about one nautical mile.

There is no more beautiful sight, manmade or natural, than that of a graceful bird in the air.

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