Developmental History of the
McDonnell FD-1 or FH-1 Phantom

The Navy formally accepted the XFD-1 in Sept 1947. The other had crashed by then, and was never accepted.

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The United States Navy's first all-jet propelled aircraft was not a first in the United States. It was only a first for the Navy. Nevertheless the FD-1 Phantom was a landmark in carrier aviation. How it was developed, what the Navy intended it to be, and what it actually became are subjects worthy of Naval aviation history. This essay examines those subjects.

The idea of jet propulsion is practically as old as heavier-than-air flight. Very early in aviation history, engineers recognized that their attempts to improve maneuverability at high speed and high altitude were restricted by the power and size of piston engines, and it was generally understood that jet propulsion could alleviate many of these limitations. Despite the advantages of jet engines, however, serious research into their possible application to aircraft remained for years mainly in the theoretical stage. Not until the 1930s did they become candidates for applied investigation. The first jet-propelled aircraft in the world, the Heinkle HE-178, flew in Germany in August 1939. The first in England occurred on 15 May 1941 with the flight of the Gloster-Whittle E-28. In the United States, things moved more slowly, but the obvious reality that jet-powered military aircraft would soon be in some nation's operational inventory could hardly be ignored. The European developments spurred the Untied States to action. The British agreed to an American request that they grant to the U. S. Army the manufacturing rights for the Whittle engine. The Army in turn contracted with General Electric to produce the powerplant and with the Bell Aircraft Company to build an airframe. On 1 October 1942, the Bell XP-59, powered by two GE I-16 engines, made the first jet propelled flight by an aircraft in the United States.

That the Navy was slow to get a jet aircraft aloft is not surprising. It is one thing to put a jet engine in an airframe and make the combination fly,

but it is quite another thing to render that combination suitable for carrier operations. It was a repeat of the very early days of aviation itself. The Army bought an aircraft in 1909; the Navy forestalled a similar purchase until 1911. Conservative Naval officers who witnessed aircraft flying often made a quaint observation about them: "They flew, but what else can they do"? The Navy accepted aircraft only after someone had demonstrated that flying machines could work with, and benefit, the fleet at sea. The same attitude prevailed toward jet-propelled aircraft; only in the latter case it was the aviators themselves who were being cautious.

In October 1942, the Bureau of Aeronautics (BuAer) issued a contract to Westinghouse to build a turbojet engine of its own, Westinghouse's, design. Three months later, January 1943, a letter of authorization went from BuAer to the McDonnell Aircraft Corporation to design and build two experimental class VF aircraft. They were to fly by jet engines only. A month later, in February, BuAer awarded still another contract to the Ryan Aeronautical Company to build three class VF aircraft that would each be powered by a conventional reciprocating engine driving a propeller but equipped also with a turbojet engine to provide auxiliary power to improve take-off and high-speed performance. The McDonnell aircraft was designated the XFD-1; the Ryan aircraft was the XFR-1. That these two contracts were awarded so closely together demonstrates what the Navy was trying to do with jet propulsion; it also places these two dissimilar aircraft in their appropriate historical roles.

In developing jet aircraft for its own use, the Navy faced three problem areas. One of these areas was the design of airframes for high-speed flight, nearly the speed of sound. It was a problem that could be solved by aerodynamicists and designers only with the knowledge gained through

experience.[1] The other problem area was take-off and low-speed flight. In those early days of jet aviation, the aircraft had only slightly more thrust than was needed to overcome friction during take-off and to overcome the air resistance in low speed flight. Therefore, free take-off required a long ground run; for carriers this requirement meant that very few aircraft could be spotted on deck.[2] In making a landing approach, the aircraft had an equally serious problem because it possessed very little reserve power to fall back on to adjust its flight path or to take a wave-off. The third area of concern was the jet engine's high fuel consumption. Considering the size limitations that were recognized for carrier fighters, it seemed that the range of jet-propelled fighters would be substantially less than what was necessary for carrier aircraft. These three problems explain the Navy's late entry into the area of jet-propelled flight.

Once the Navy decided to go ahead with jet aircraft, a split appeared in opinion as to what kind of jet aircraft to build. Two schools of thought surfaced among Navy aeronautical engineers. One held that the requirements for reserve power for take-off and landing, and the need for fuel economy for the sake of range, could be satisfied by turboprop fighters. Others believed that the shortcomings of an all-jet aircraft could be overcome eventually through development. Of course, the latter view prevailed, but it is interesting to note how long the former view hung on. As late as the early 1950s, BuAer was expressing an interest in the Air Force's XF-84H which was a modification of Republic's RF-84F Thunderstreak modified to take an Allison XT-40-A-1 turboprop. But this interest soon afterward died out and it was the last example of Navy interest in a turboprop for carrier combat aircraft.[3] On the other hand, the Ryan FR Fireball can be seen as a third approach to jet aviation. Combining as it did a jet engine and a propeller powered by a

piston engine, the Fireball showed some promise toward resolving the three problem areas of jet aircraft aboard carriers. It made its first flight on 25 June 1944 thus becoming the first Navy aircraft to be powered by a jet engine. There were extensive tests on the FR and carrier qualifications were conducted, but many deficiencies were present and never overcome. The Navy accepted 69 Fireballs and assigned some to squadron, but withdrew all of them by July 1947.[4] The combination of jet and piston engines did not survive the FR. Nonetheless, the turboprop engine is still very much a part of Naval aviation, but not in fighter or attack aircraft.

The XFD-1 was exactly what its designation implied. It was an experimental fighter aircraft from the standpoint of being new and being one of three options open to the Navy for testing jet aviation. It may have seemed risky for the Navy to take such a radical innovation to a small, new company such as McDonnell, but the company's being new and small was actually in its favor. The larger and more established manufacturers were busy with wartime production orders. McDonnell had the time to work on a new concept. BuAer determined that McDonnell had the engineering man hours and the competence to handle the task.[5] The Letter of Authorization went to McDonnell on 7 January. The contract itself is dated 30 August 1943; it is specified as a Negotiated Contract. It calls for design data, tests, static test structure representatives of the aircraft, two class VF aircraft designated XFD-1, final corrected information and aircraft drawings, and final corrected information tool design and aircraft drawings. A cost plus fixed fee contract, its total estimated cost was $2,377,862.50 with a fixed fee of $100,000.[6] These dollar figures are mentioned here solely as conversation pieces. In reality they are meaningless and have been for many years. It is impossible to translate dollar figures over ten years, let alone over forty. The contract with

McDonnell called for the design and manufacture of two experimental aircraft, not for two fighter aircraft. Some observers may choose to see $2,377,862 as a bargain by today's standards, perhaps it is, providing NAVAIR wanted to procure two XFD-1 aircraft.

The contract that ordered the XFD-1 was of the negotiated type, that is not the result of a competition. Because the aircraft was experimental, BuAer had the authority to negotiate the contract without competition. But during World War II, all services had the unusual authority to contract without going through the legally prescribed steps of a competitive buy.

What did McDonnell's designers come up with?[7] (The XFD-1's detailed characteristics, and a photo, are in enclosure (1).) It was a basic fighter aircraft with an estimated empty weight of 5,630 pounds. It had provision for four fixed 50 calibre guns which were considered adequate to defeat the enemy aircraft of the day. By comparison the F4F-3A had an empty weight of 5,232 pounds; the F6F-3 a weight of 9,101; and the F4U-3 weighed empty 9,039. If basic, post-contract developmental problems were noted, they were not serious enough to gain lasting mention.[8] The aircraft's development was quite rapid and it was ready for flight before its engines could be delivered.

It was around the Westinghouse 19B jet engine that McDonnell built the XFD-1 airframe. Westinghouse, unaided by British experience, had developed a jet engine in a surprisingly short period of time.[9] The first 19B was tested on 11 October 1944 and revealed a specific fuel consumption of 1.08 pounds per pound of thrust per hour at 15,000 r.p.m.[10] This engine performed well enough in the October tests to be delivered to the McDonnell plant, but the XFD-1 needed two engines and only one was on hand; a second was simply unavailable due to technical difficulties. As a result, McDonnell engineers had to be content with installing the single engine and conducting taxi tests at their

plant. The second engine finally arrived, and on 26 January 1945 the XFD-1 flew for the first time. The aircraft flew twice that day for a total flight time of 49 minutes. By February, the XFD-1 had flown for five hours in nine flights. The only serious problem was an engine failure due to foreign object damage to the forward bearing of the oil system. There was some fuel system friction, and some other fuel difficulty attributed to vapor lock.

The airframe itself performed about as expected. In October 1944, engineers had forecast calculated flight characteristics in light of Navy specifications for stability and control characteristics of airplanes. Their estimates are interesting compared to actual flight data. They estimated that the XFD-1 would be satisfactory with the exception of excessive aileron control forces, and they suggested that spring tabs be added to the ailerons to ameliorate this condition. They had doubts about the suitability at high speeds of the XFD-1's beveled trailing elevators. They acknowledged that tests had indicated satisfactory control forces with the elevators, but they cautioned that the effect of increasing Mach number was to overbalance beveled control surfaces. An alternate horizontal tail incorporating sealed internally balanced elevators was tested on the model. Results indicated that stability and control were satisfactory if a ten pound constant-force spring were incorporated in the elevator linkage to produce stick-free stability with military power and for aft center of gravity position in steady straight flight.[11] McDonnell's preliminary evaluation determined that the first aircraft article was directionally stable laterally and longitudinally in the landing condition. At high speeds it suffered a slight deterrioration of stick-free longitudinal stability. (This defect was corrected on the second XFD-1 article by a revised horizontal stabilizer incidence). There was also some excessive aileron system friction and slight directional oscillation at

high speed.[12] But overall the XFD-1 aircraft was impressive enough to induce BuAer to offer McDonnell an order for 100 production models in February 1945.

While the production model was under development, testing continued on the two XFD-1 articles. On 24 August 1945, the second XFD-1 (Bureau Number 48236) made a belly landing caused by a loss of power during a landing approach. The pilot had switched fuel tanks at about 250 feet altitude and the engines ceased combustion without subsequently resuming. There was no reason to believe that the engines themselves were responsible for this loss of power.[13] The aircraft itself was not seriously damaged. But a worse crash was in the offing. On 1 November, the first XFD-1 (Bureau Number 48235) emerged from the shop after undergoing revision in aileron design. During its test flight, the aileron locked in the up position and the aircraft crashed to complete destruction.[14] Despite this misfortune, the remaining XFD-1 was performing well enough to be taken to the Naval Air Test Center at Patuxent River, Maryland to begin Navy testing.

The aircraft arrived in April 1946, but its testing was hampered by non-availability of engines. Westinghouse was having a labor strike and two spare 19B engines were unavailable until May. The Patuxent River tests were encouraging. By July, the XFD-1 went aboard USS Franklin D. Roosevelt (CV-49). The carrier trials of the aircraft took place on 21 July. They included several take-offs and landings, but always with a brisk wind. No catapult was used. But the aircraft demonstrated that it could operate successfully from a carrier of the Roosevelt class. Beyond that date, serious doubts about the adaptability of jet-powered aircraft to carrier aviation were laid to rest. From that point on, the questions were mainly of refinement. The XFD-1 was limited in range and speed, but its purpose was to test the feasibility of jet aviation for the Navy. On 21 July 1946, the aircraft

justified its existence.[15]

One thing that was obvious was the need for catapults with jet aircraft. To shorten take-off distance and allow more planes to be spotted on deck, catapults were simply unavoidable. Interestingly enough, however, the XFD-1 was not the first all jet aircraft to be catapulted from a carrier. That honor goes to the U. S. Army's F-80 Shooting Star. On 1 November 1946, Major Marion Carl, USMC, piloted an F-80 twice from the Roosevelt's catapult. These catapults were the H4B type designed to launch a 28,000 pound airplane at 90 mph in a 150 foot run.[16] The XFD-1 was not used for this experiment because it was unavailable. Following completion of the July flights aboard the Roosevelt, the aircraft suffered a mid-air collision with a buzzard. The leading edge of the starboard wing and the right horizontal stabilizer sustained damage. The aircraft was returned to the McDonnell plant in St. Louis for repairs.[17] By 1 October the aircraft was repaired and had resumed flight tests, but with completely redesigned ailerons.[18] At the time that Major Carl was making his catapult launch in the F-80, the XFD-1 was still undergoing aileron development flight testing.

The XFD-1 ended its test program without a final word being written. In December 1946, its demonstration was canceled.[19] In January 1947, it was placed in dormant status to be used in the future only for minor flight test items.[20] The XFD-1 dropped out of active flight testing because it had served its purpose and was overtaken by events. Overall, the twin-engine jet from St. Louis performed well considering the state of the art. As a testimony to its success, the Navy gave McDonnell a production order for 100 improved XFD-1 aircraft.[21] The production model was designated FD-1.

The improved FD-1 naturally attracted greater interest than its experimental predecessor. There certainly were structural differences in the

two aircraft. (Enclosure (2) presents the characteristics, two photos, and a cutaway of the FD-1.) The FD-1, had greater fuel capacity and its two Westinghouse J30 engines had higher thrust than the engines in the XFD-1. It had a modified fuel system, modified gunsight and instrumentation arrangement, and a modified seat position. It was a heavier and longer airframe than the X model but had a shorter span. The empennage was redesigned.[22]

The FD-1 made its first flight on 28 October 1946.[23] It arrived for testing at Naval Air Test Center, Patuxent River, Maryland in February 1947.[23] On 23 July 1947, VF-17A took delivery of two FD-1s.[25] On 28 August, the Navy changed McDonnell's designation letter from D to H thus changing the FD-1 to the FH-1.[26] By that time, the aircraft was officially known by the popular name Phantom. The designation change did not, however, affect the XFD-1; its designation never changed and it was only unofficially known as the Phantom.[27]

What kind of aircraft was the FD-1? For its day, it was acceptable, but it had an insurmountable limitation because of fuel supply. This shortcoming, however, was basically a design problem and could be corrected in a different type of airplane. As an escort, the Phantom was only partially successful. It consumed excessive fuel while climbing with the attack group. Attempts to climb on one engine proved not to be practical. Below 150 knots, the FD-1 could not maintain an active and positive defense, but with speed brakes extended it could follow an attack dive and keep up close support of the attack bombers throughout their run. Its ordnance characteristics were acceptable. The aircraft proved to be a steady platform below 375 knots. The stick forces were comfortably light; only small changes of tab setting were necessary to compensate for speed changes between 250 and 400 knots, but beyond 375 knots the pilot found it virtually impossible to regain his point

of aim once he had lost it. Pilots also reported that at these speeds only the slightest movements of rudder and ailerons produced a lateral oscillation that could be controlled only with difficulty. But the FD-1 had such good zoom climb and fine speed that it could gain positions for repeated runs on 200-250 knot targets without difficulty. Its high speed and maneuverability made it an excellent weapon for strafing attacks. It could effect a highly evasive approach to a target and easily roll into an attack dive. The speed brakes gave it excellent performance when attacking a surface vessel. In a 55 degree dive from 13,000 feet with speed brakes all the way open, and engines at idle, the aircraft's speed did not exceed 360 knots (indicated air). When retiring, the brakes could be fully closed without producing an objectionable change in longitudinal trim.

How did the Phantom compare with other Naval carrier-based fighters? Against the Grumman F8F-1 Bearcat, the FD-1 made a favorable impression. For example, in zoom climb from 15,000 feet, the Phantom gained an average of 13,700 per minute; the Bearcat gained 11,600. But the differences were not all so clearly favorable. In radius of turn at normal rate of power and full internal fuel load, the Bearcat had a discernible advantage, but with a half load of fuel in the Phantom, the Bearcat's edge disappeared. The FD-1 had lighter aileron forces and was easier to handle at high speeds. In maneuvers against the Vought F4U-4 Corsair, the Phantom was able to out-turn its adversary in a dog fight.

The FD-1 no doubt qualified as a carrier-based fighter in most regards, but operationally it was restricted by range and endurance. It is true that the aircraft gained in fuel economy at high altitude, but this saving was offset by fuel consumption during climb. The addition of an external fuel tank reduced its speed seriously enough to hamper its tactical value. For

these reasons--speed and endurance--the FD-1 was not accepted by the Navy as a front line, carrier-based fighter. It was accepted interimly as an interceptor. In this role, the Phantom could perform effectively because of its high speed and fast zoom climb to good position.[28]

On 5 May 1948, VF-17A qualified as a carrier-based jet squadron with sixteen FH-1 Phantoms. In three days of operations aboard the USS Saipan (CVL-48) all squadron pilots, and Commander Air Group 17, were qualified with a minimum of eight takeoffs and landings per man.

It should be noted that the Phantom had many of the usual problems that afflict carrier-based aircraft. There were initial difficulties with the arresting and launching gears. A problem arose concerning swivel in the nose wheel, the fairing for the hold-back fitting had to reinforced, the tail hook was not at first in a truly efficient mode. But these were all minor design problems and were rectifiable. Also rectifiable were the difficulties caused by handling jet-propelled aircraft aboard carriers.

Finally, we have to admit that most of what was wrong with the FD-1 was rectifiable; not in that particular airframe, of course, but in subsequent models. In this reality lies the true contribution of the FD-1 Phantom. It was ordered and designed to determine the feasibility of jet-powered aircraft operating from carriers. It proved that the concept was feasible. It also proved correct those early aerodynamicists who believed that jet-propulsion's problems could be solved through development. It demonstrated that the Navy could enter the age of jet aviation, and could best enter it with aircraft powered by all turbojet engines.

Postscript

The Navy procured 59 complete articles of the FD/FH-1 aircraft. Some of them served in squadron until July 1950. The direct descendants of the aircraft were the F2H Banshee, the F3H Demon, and the F4H (F-4) Phantom II.

1. This paper is not the place to discuss this problem in detail. For a general survey of the subject see Richard P. Hallion's Supersonic Flight, The Story of the Bell X-1 and the Douglas D-558, MacMillan Company (New York), 1972.

2. It was about half-way through the Second World War before the Navy recognized catapulting as the primary method of launching aircraft from carriers.

3. BuAer expressed an interest in this aircraft, no doubt about that. How much interest is another question. The Air Force ordered two prototypes. Some writers claim that the Navy entered into a joint agreement with the Air Force to procure a third XF-84H. However, the NAVAIR history office has been unable to document this agreement and knows of no one who has documented it. It is certain that the Navy never owned an XF-84H.

4. An acccount of the FR's development and deficiencies appears in the BuAer W.W.II Divisional Histories (Vol.III, Engineering Division, Part 12,VF Design Branch). See also the BuAer Divisional Monthly Progress Reports.

5. Ltr of Request for Authority to Contract from BuAer to Secnav of 2 Jan 1943, subj: Letter of Intent from Navy Dept. to McDonnell Aircraft Corp.

6. Bureau of Aeronautics Contract Number NOa(s)161.

7. The various designs that McDonnell's engineers considered are not explained here. They belong more to aviation history, or to McDonnell's history, than to Naval history. Some authors have observed that the XFD-1 bore a resemblance to the McDonnell XP-67 which the company designed for the USAAF. An observer must look hard to find the resemblance.

8. The sources are silent as to what Lcdr. Pearson and Lt. Gavin of the BuAer VF Design Branch saw at that mock-up at the McDonnell plant. Where such comments are usually found, there is none, nor anywhere else that has thus far been researched.

9. Secrecy surrounding British jet engines was an enduring problem.

10. Navy Department, BuAer, Ten Year History and Program of Future Research and Development: Naval Aircraft, Equipment and Support Facilities, Vol IV, Aircraft Power Plants (Washington, D. C., BuAer, 1945), pp.28-30 (Known also as Meade Report). See also the BuAer W.W.II Divisional Histories, Vol III, Engineering Division, Part 12, VF Design Branch, "Navy Jet Developments."

11. NACA Memorandum for BuAer No.A4J31 of 31 October 1944, "An Estimation of the Flying Qualities of the McDonnell XFD-1 Airplane."

12. BuAer W.W.II Divisional Histories, Vol III, Engineering Division, Part 12, VF Design Branch, "Navy Jet Developments."

13. BuAer Progress Report of VF Design Branch for August 1945. The pilot apparently had not yet lowered the landing gear. When the engines flamed out, he had no power to get the gear down thus necessitating a belly landing.

14. BuAer Progress Report for November 1945, VF Design Branch.

15. The XFD-1, not the FD-1 made these flights. Some confusion has existed on the subject. For reference see BuAer Progress Reports of VF Design Branch for July through October 1946.

16. BuAer W.W.II Divisional Histories (Vol III, Engineering Division, Part 8, Ships Installation Branch).

17. BuAer Progress Reports of VF Design Branch for July 1946.

18. Ibid., for October 1946.

19. Ibid., for November 1946.

20. Ibid., for December 1946.

21. Curtailment of wartime production after VJ Day cut this order from 100 to 60.

22. Ibid., for January 1946. One of these items should be mentioned as an example. From November 1947 to February 1948, the Naval Air Material Center at Philadelphia used the XFD-1 in icing test atop Mt. Washington in New Hampshire. The tests are evaluated in reports on NAMC Project TED No.NAM-PP3103.

23. BuAer W.W.II Divisional Histories Engineering Division, Vol III, Part 12, VF Design Branch.

24. BuAer Progress Report of VF Design Branch for October 1946.

25. Ibid., for February 1947.

26. Ibid., for July 1947. Both the McDonnell and Douglas Companies were pleased to see the confusion ended between their products.

27. Ibid., for October 1947. The use of the name Phantom first appears for the FD-1 in the BuAer Model Designation of Naval Aircraft (SH-3AW) in October 1945. In that issue, the XFD-1 also appears, but without the name Phantom. In fact the XFD-1 never officially was called the Phantom, but someone painted the words THE PHANTOM in white letters on the XFD-1 airframe itself. When the McDonnell F-4 was given a popular name, the name Phantom II was chosen. This choice has caused the FD-1 to be anachronistically called Phantom I.

28. A variety of reports were used to compile this description of the FD-1's characteristics.