Engineering Success: Pratt & Whitney Aircraft, 1925-1940

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Put all your eggs in one basket – and then watch that basket!
–Andrew Carnegie [quoted in Morison, 1966, p. 195]

The Pratt & Whitney Aircraft Company was incorporated in 1925. As a case study, the spectacular success of the first fifteen years of the Company illustrates the interdependence of technical excellence, market conditions, and managerial decision-making. Guided by the vision of Frederick B. Rentschler and the engineering skill of George J. Mead, the company focused on design and production of air-cooled radial engines, the type preferred by the Navy. Since the Navy was the major market, it is no surprise that air-cooled radials underwent rapid development and came to dominate the aviation industry in the period between the World Wars. Rentschler's network of business and government contacts, and his particular approach to product development, were instrumental in engineering the early success of his company.

Background and Genealogy: 1910-1925

Prior to World War I, civilian aviation in America had been primarily a matter of barnstorming and stunt flying. There was little motivation to improve engines, nor an extensive market to spur competitive engineering. Although powered flight had been pioneered in the United States (with the Wright brothers manufacturing their own engine), by 1916 the complaint could legitimately be made that "There is not a good American motor made" (Roland, 1985, p. 35).

With war brewing in Europe, and American involvement increasingly likely, the armed forces became a potential large market for improved aeronautical engines. Two separate lines of development ensued, each having strong influences on the eventual formation of Pratt & Whitney Aircraft.

One line began with a meeting between the engine manufacturers and representatives of the military air arms on June 8, 1916. "J.G. Vincent, of the Packard Motor Car Company, and E.J. Hall, of the Hall-Scott Motor Car Company, took over a hotel room in Washington for nearly a week and

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designed the 8- and 12-cylinder Liberty power plants with prevalent engineering and mass-production procedures in mind" [Bilstein, 1984, p. 37].[1]

The second line of development began with a license to produce Hispano-Suiza ("Hisso") engines. The Wright Company (later Wright-Martin, Wright Aeronautical, and Curtiss-Wright) acquired the license in 1916 [Smith, 1981, p. 68]. During the War, the Wright Company worked closely with the military Aircraft Production Board. One Navy officer detailed from the Board to Wright-Martin was Frederick B. Rentschler, a thirty-year old Princeton graduate with a strong background in automotive engines [Pratt & Whitney Story pp. 16-18]. His main activities at Wright-Martin were administrative, though he became intimately familiar with the quality of work done by such hands-on engineers as George J. Mead, an MIT graduate who later joined Rentschler in founding the Pratt & Whitney Aircraft Company.

The intimate association between the aeronautical manufacturers and their military clients continued through and after the War, and became one important ingredient in the strength of the industry. The Navy's continuing direct communication with industry executives was a strong factor in the subsequent establishment of Pratt & Whitney Aircraft.

Aviation's contribution to the war effort was significant enough to convince the American military that strong air forces would be crucial to the successful prosecution of future wars. Strong air forces, in turn, would depend on a thriving domestic aviation industry [Rentschler, 1950, pp. 5-8; Schlaifer, 1950, pp. 7-14; Trimble, 1990, ch. 4; Trimble, 1994, p. 116].

After the armistice, however, the military weakened the aviation industry by abruptly canceling contracts and by dumping surplus aircraft on the civilian market. The aircraft construction industry shrank to a bare tenth its wartime size (Roland, 1985, p. 51). Rentschler later commented "...when the Armistice came all the companies who carried on our chief aviation activities blithely went back to automobile manufacture, so the aviation industry did not even get any real or lasting results..." [Rentschler, 1950, p. 6].

The Wright-Martin assets had been sold to the Mack Truck Company, with approximately three million dollars set aside "for the possible formation of a small postwar aviation company." Rentschler was appointed CEO, and asked to assemble personnel for the new Wright Aeronautical Company (Rentschler, 1950, p. 7). The principal client continued to be the military, and Rentschler's contacts with the Navy were an additional asset over and above his demonstrated managerial skills.

The demands of the military market proved a strong motivation for aviation manufacturers' research and development. The engineering search began: which of the many possible engine types was capable of the sort of improvements which would be attractive to the military? Some engine types proved to have intractable negative characteristics when attempts were made to scale them up.

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[1] For a more detailed account of the Liberty engine's development, see Schlaifer [1950]; and Smith [1981].

For example, the rotary engine had been almost satisfactory at the low speeds typical of WW I aircraft, although the castor-oil fumes billowing from the engines into the open cockpits were reputed to have caused more than one pilot to make an emergency landing in order to answer the call of nature. (If the delicate moment occurred over enemy territory, the hapless pilot might find himself a POW [Smith, 1981, p. 63].) When the rotary was scaled up, the gyroscopic effect of the rotating engine became unmanageable and the aircraft could not be easily steered.[2]

In other cases, superiority of one engine type over another could not be so easily established. This was the situation with the competition between air-cooled and liquid-cooled engines, and between those in which the pistons were arranged like spokes of a wheel (called radial) and those where the pistons were in straight-line or V configurations. Incremental technical advances could swing the balance between one type and another. For military purposes, the short nose length and light weight of an air-cooled radial were potentially attractive features.

The newly reorganized Wright Aeronautical Company began operations by providing improved liquid-cooled V-8 Hisso-type engines to the Army. George Mead had made a comprehensive study of engines during his stint at the Army's McCook Field, and felt that this was the most promising avenue.

Meanwhile, a workable air-cooled radial engine had been developed by one Charles Lawrance. His company was very small, and ran into financial trouble. The directors approached Wright Aeronautical about a merger, which Rentschler at first opposed. As Rentschler later recalled,

> ...Admiral [William F.] Moffett, then the head of the Bureau of Aeronautics, asked me to come down and talk with him about the Lawrance situation. He said definitely the Navy was interested in the type and was proposing to concentrate on air-cooled radials for that size [Rentschler, 1950, pp. 9-10].

Rentschler reversed his recommendation, and Wright Aeronautical acquired the Lawrance Aero-Engine Corporation. Rentschler continued to keep a tight rein on the company, and a weather eye on the requirements of the Navy. When it became apparent that the Navy would insist on continued development of the air-cooled radial, and the directors at Wright Aeronautical balked at the level of attendant expense and effort that Rentschler thought appropriate, Rentschler resigned as president. (Byttebier, 1972, p. 75; Rentschler, 1950, p. 10).[3]

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[2] It should be noted that the rotary engine of the 1910-1920 period differed significantly from the modern automotive engine bearing the same designation, especially in the fact that the early engine rotated in its entirety around the crankshaft [Smith, 1981, p. 58].

[3] Lawrance was a vice president of Wright Aeronautical, and became president after Rentschler's departure. It would not be surprising if there were some coolness between Lawrance and Rentschler, reflected in the subsequent rivalry between their firms. In an address before the Royal Aeronautical Society in England, Lawrance mentions the Simoon "which has just completed a full 50-hour test" and two other American radial engines under

Formation of Pratt & Whitney Aircraft

About a year later, in the spring of 1925, Rentschler was ready to re-enter the aeronautical engine business. The year was one of transition for the aviation industry as a whole, moving from the use of war surplus planes for barnstorming, stunt flying, and offering thrill rides, to developing serious commercial businesses based on the capabilities of more modern equipment (Osborn, 1925).

The Curtiss Exhibition Company advertised that they had now "disposed of their surplus JN airplanes under their offer of a free plane with each flying course" and went on to suggest that patrons consider the "Complete Course, including Flying and Mechanical Training...$300" (this was accomplished in ten hours) or "Flying instruction by the hour...$35 (no deposit required to cover breakage)" (*Aviation*, Jan 5, 1925, 4; Schlaifer, 1950, p. 160).

Robertson Aircraft Corporation advertised that eight to ten hours of instruction "should complete the most stubborn case, and from then on, the refinements...can be gained only from experience." Robertson's ad went on to say "Commercial aviation is a rapidly growing industry. Don't delay! Enroll now!" (*Aviation*, June 15, 1925, p. 659) The aircraft offered for sale in these ads were light one- and two-seaters, powered by 150 hp engines such as the early Hisso and OX-5.

"Commercial aviation" was clearly envisioned as an enterprise for independent businessmen flying short hauls. Crop-dusting operations are one such opportunity mentioned in an advertisement for the Wright Whirlwind 200 hp J-4 engine. The advertisement explicitly cites military adoption of the Whirlwind as a positive selling point, evidence of the engine's "unusual dependability, high performance, ease of inspection, adjustment and minor repairs and the low cost per flying hour" (*Aviation*, June 15, 1925, p. 660).

Foresight is always risky: there are always predictions, plausible enough at the time they are made, which turn out to be spectacularly off the mark; a 1925 editorial in the trade journal, *Aviation*, saw a poor market outlook for planes to be flown by highly paid professionals, and opined "the largest potential field for planes is the amateur user...until a plane is built which is safe for the amateur there will only be a limited market for specialized planes" (*Aviation* , Mar 30, 1925, p. 341).

The largest sector of the limited market was still the military, and Rentschler was positioned to make the most of it. He had retained his connection with the Navy, and had been reassured by Admiral Moffett that the Navy remained eager to purchase air-cooled radial engines in the 400 hp class from a civilian industry; the alternative would be to develop the Navy's own design and production capacities far beyond that required for peacetime.

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development in the 400 hp class, but omits any notice at all of the Pratt & Whitney Wasp. Charles L. Lawrance, "Modern American Aircraft Engine Development" *Aviation*, March 22, 1926 p. 411-415.

Rentschler's plans offered an opportunity to strengthen the civilian industry, to promote equitable pricing policies, and to stimulate further innovation.[4]

Rentschler was also well-connected to the business establishment: his elder brother Gordon was executive vice-president of the National City Bank of New York, and Frederick Rentschler himself was acquainted with many influential people both through his family's business and through friendships and acquaintances made at Princeton and in the Navy. There was risk, as always, in starting a new company, but Frederick Rentschler was the type of man that would please the heart of any capitalist. As one of the long-time Pratt & Whitney engineers, Leonard S. Hobbs, later recalled, "He worked very hard, and he fixed it so he knew everybody. This was back in the early days more, but he knew everybody in the Air Force and the government, the Navy particularly...Forrestal was his brother's roommate in Princeton; he was an old friend of Lovett's, the second Secretary of Defense..." (Hobbs, 1970).

Gordon Rentschler suggested that Frederick see their family friend James K. Cullen, who in turn gave him a letter of introduction to Clayton Burt, general manager of the Pratt & Whitney division of the Niles-Bemont-Pond Company. Pratt & Whitney was an established name in the tool business, and had both idle capital and an idle plant in Hartford. Within days, the deal was done; Rentschler should assemble his team, and the Pratt & Whitney Tool Company would provide capital and workspace.

Rentschler recruited a half-dozen men in the next few weeks. His first hire was George Mead, who would be vice-president and head the engineering department. Knowing that Wright Aeronautical would enter its new Simoon air-cooled radial for the Navy's consideration by early 1926, the engineers felt the pressure of time. If Pratt & Whitney Aircraft couldn't submit its own contender before the Navy standardized on the Wright entry, all would be lost.

George Mead and Andrew Wilgoos worked through June and July in Wilgoos' garage to design the company's new engine, well before Pratt & Whitney Aircraft's official incorporation on August 1. Earle Ryder, another of the "first official employees," assisted Wilgoos in July. Ryder recalled "[w]e set up a couple of drawing boards on packing cases..." and laid out the "essentials for the engine." In the 1920s, design was more art than science:

> You apportioned your parts so they looked right and a good mechanic could pretty well tell what they needed. That was one of Andy Willgoos's strong points. He was a natural mechanic and had a feel for machinery of all kinds. He didn't need any pencil work to tell him how a thing ought to be made (Ryder, pp. 12-13, 41).

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[4] Moffett's biographer describes Moffett's dilemma in the early 1920s: "it [w]as the government's responsibility, in the absence of a viable commercial outlet for the products of the aviation business, to do all it could to encourage the industry, knowing that 'if war should break out there would be a tremendous urge to get what we need in the shortest possible space of time." [Trimble, 1994, p. 116; see also Trimble, 1990, p. 66.]

Pratt & Whitney's new engine, the Wasp, was ready for testing within six months. It performed extremely well, and the Navy chose it for their standard in the 400 hp class. The less powerful Wright Whirlwinds (150-200 hp class) continued to be used for Army and Navy trainers.

The Wright Simoon engine was announced in the February 1, 1926 issue of *Aviation*; the Pratt & Whitney Wasp made its debut in the issue of February 15. Each was tested by the Navy in the standard bench procedure and flight-tested in actual aircraft, in this case the Wright Apache. The Wasp far outperformed the Simoon, and went on to become the parent of an extremely successful family of engines.

Although the Wasp was designed to suit the Navy's requirements, Pratt & Whitney marketed it to general aviation as well. The February 15th issue of *Aviation* carried an elegantly spare advertisement: a frontal view of the engine, resembling a sunburst, with the simple caption "Introducing The 'Wasp'." An article in the same issue stressed such qualities as reliability, durability, high safety factor, and ease of maintenance. The article also notes "The efficient cooling enables the engine to develop full power on domestic aviation gasoline, which is an important consideration."

Additional details of the bench and flight test results appeared in May. "For the first time, a radial type engine in the 400 hp class compares more than favorably with the efficient water-cooled types of engines on a dry weight per horsepower basis." The Office of the Secretary of the Navy is quoted: "A number of new airplanes for shipboard use are being built around this engine... There is every assurance that, as a result of this development, the fleet will soon have aircraft whose performance is far in excess of anything available elsewhere."

Tucked inconspicuously near the end of the article is Frederick Rentschler's announcement that Pratt & Whitney Aircraft has added two men to its Board of Directors: Charles F. Kettering of General Motors, and William B. Mayo of Ford. The choice was well calculated; both men were trained engineers, and not likely to be short-sighted about the need for continued research and product development. Further, Mayo had "directed the...aviation operations of that company" (*Aviation*, May 31, 1926, pp. 827-828); the Wasp engine was soon installed in a Ford airplane (*Aviation*, April 25, 1927, p. 620). Pratt & Whitney shipping records show, however, only one Wasp engine sold to Ford in 1926 (United Technologies Archives).

By August, the advertising for the Wasp showed a detailed side view of the engine, ticking off the engineering achievements: "Exclusive Reasons for Leadership: Valve Mechanism – completely enclosed; Nose – clean and free from accessories providing for excellent cowl lines; Solid Master Rod and Split Crankshaft – provides for high speed; Main Crankcase – Divided – maximum strength with minimum weight; Accessories – all located behind mounting – accessible and weather proof; Mounting Flange – approximately on center of gravity; Supercharger – built in G.E. type; Cylinders – Unusual provision for cooling; Lifting Hooks – on center of gravity" (*Aviation*, August 2, 1926, p. 199).

At Wright Aeronautical, Rentschler had been unhappy with what he saw as their lack of commitment to continued improvements in their engines; he did not let his Pratt and Whitney team make that mistake. Almost immediately after inauguration of the Wasp engine, Pratt & Whitney introduced a larger and more powerful sibling, the Hornet. At 1900 r.p.m., the Hornet developed 525 horsepower compared to the Wasp's 425. As *Aviation* noted, "From a service...standpoint, it is of unusual interest to know that approximately 80 per cent of the total parts of the Hornet and Wasp are identical... The entire accessory ends of the engines are exactly alike, including even the mounting flange, so that Wasp and Hornet engines can even be interchanged readily in the same type of airplane" (*Aviation*, May 2, 1927, p. 897). One can easily understand the importance of such a feature to both the logistics- and spare-parts-minded Navy market and to the industry as a whole.

Developing Markets

In the period 1925-1930, civilian aviation was still the glamorous province of individuals, but the early phases of the more mundane workaday industry were beginning to appear. Aircraft manufacturing increased dramatically; the number of establishments producing aircraft grew from 44 in 1925 to 132 in 1929, and the value added grew from $9,654,752 to $43,784,821 in the same period. The number of persons employed in aircraft manufacture increased as well, from 2,701 in 1925 to 14,710 in 1929 (*Fifteenth Census*, pp. 1189-1192; *Sixteenth Census*, pp. 540-542). Pratt & Whitney Aircraft shipped 260 Wasps in 1927; by 1929, the number shipped rose to 1656 (*Records* 1933-35).

The exploits of aeronautical record-setters drew attention to aviation; such commercial enterprises as cargo transport, air mail, and passenger service rode their public-relations coattails while military clients provided the economic foundation for continued development of the industry. Airmail contracts directly subsidized and encouraged passenger traffic, and flying began to acquire a new image in the public consciousness. Speed-minded businessmen braved the perils of open-cockpit planes, or later enjoyed the relative comfort of small, unpressurized closed cabins.

The nascent commercial market and the established military role are evident in a 1927 advertisement for the Wasp: "In a Ford Air Line Transport the 'Wasp' has demonstrated its ability to carry 33-% greater pay load than the previously used water cooled powerplant of approximately the same power. It is becoming apparent that the 'Wasp' will find the same useful application in the commercial field as it has in Naval aeronautics" (*Aviation*, April 25, 1927, p. 620).

However, the major market for Pratt & Whitney's 400 hp engine remained the Navy; Congress in 1926 funded five-year aircraft procurement programs for the military, which provided the security and stability needed by the manufacturers (Trimble, 1990, p. 75). Pratt & Whitney gave the Navy their highest priority; shipping records for 1926 show that all but one of the first 213 Wasps were sold to the Navy (the odd one was sold to Ford, and was probably

the engine referred to in the advertisement mentioned above). Not until 1927 were 25 Wasps sold to Boeing, to replace the Liberty engines in Boeing's Model 40A. Over 725 out of the first thousand Wasps went to the Navy. Substantial sales to commercial aviation had to wait until the field matured enough to need and demand the higher-powered engine.[5]

Personal associations were as economically important among the various segments of the aeronautical industry as they were between the industry and their clients. Frederick Rentschler had asked advice of Chance Vought before organizing Pratt & Whitney Aircraft; he had been acquainted with William Boeing since 1918. It is not surprising that in 1928 William Boeing began to institutionalize some of the informal arrangements, by purchasing companies and consolidating them under the umbrella of a holding company, eventually named United Aircraft & Transport. He first expanded his own operations, adding subsidiaries to carry airmail. Early in 1929, he acquired Pratt & Whitney Aircraft and Chance Vought Aircraft Corporation. Later that year five other manufacturers and designers of aviation equipment were added: Sikorsky Aircraft Corporation, Northrop Aircraft Corporation, Stearman Aircraft Corporation, Hamilton Aircraft Corporation, and Standard Steel Propeller. Three other airlines were also acquired: Stout Air Services, National Air Transport, and Varney Airlines. Rentschler became president of the holding company, Mead and Vought vice presidents, and Boeing held the chair (Kepos, 1994, p. 416; Pratt & Whitney, 1950, pp. 31, 73; *United Aircraft First Annual Report*, 1929). United Aircraft & Transport was well positioned to respond to all aspects of both military and civilian aviation. This vertical integration provided sufficient strength to weather the financial storms of the 1929 stock market crash and ensuing Depression.

Technical Development

The military, unlike the commercial market, required a constant stream of improvements in engine and airframe. As these were incorporated into production models, the smaller commercial market reaped the benefits – lower cost and higher quality – of the quantity production runs supported by the military.

Some of Pratt & Whitney's innovations were easily visible, such as the two-row radial design of the Twin Wasp, whose first model was rated at 1350 horsepower. Other developments to the entire Pratt & Whitney line, while improving performance sufficiently to warrant new model numbers, were less obvious: thinner cooling fins, improved superchargers and carburetors, new compositions for bearings.

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[5] United Technologies Archives. Serial numbers 216 through 240 sold to Boeing, shipping dates 17 Feb 1927 through 18 May 1927. The record bears the comment "first commercial airline engine." Serial numbers 683-727 "first commercial series" shipped 1/9/28-5/14/28; "second commercial series" numbers 729-740, shipped 4/15/28-5/21/28, to various manufacturers. Of the first thousand serial numbers, 738 are recorded as sold to the Navy.

The Balancing Act, 1930-35

The growth and improvement of infrastructure elements such as airports, radio, and navigational instruments helped support concurrent evolution of civilian aviation. As civilian aviation began to answer a wider variety of social functions, the World War I surplus engines and airframes were slowly displaced by the newer models (see, e.g., *Aviation,* March 1934, pp. 72-76; May 1935, pp. 178-180, 201). Aeronautical manufacturers trod a precarious path, dependent on government subsidy and struggling to establish a stable civilian business environment. Military procurement remained the economic backbone of the industry.

Encouraged by the Navy, Pratt & Whitney began development of the Twin Wasp and a smaller version, the Twin Wasp Jr, in 1929. The primary advantages of the two-row configuration were smoother operation, higher operating speeds (hence higher power), and smaller frontal diameter. Flight tests "in a long series of Navy airplanes" were conducted in 1931 through 1933. Production "was commenced in 1934 and from that time on...further improvements to these engines, including automatic mixture and power control carburetors, fully automatic valve gear lubrication, [and] improved cylinder cooling [resulted in] increased power and even greater dependability." The Twin Wasp and Twin Wasp Jr were eventually purchased in significant quantities by both the Army and the Navy (Olligainen, 1938*; Dependable Engines*, 1990).

Celebrity endorsement, and record-setting achievements, continued to be important throughout the 1930s. After the Granville Gee Bee taxed Jimmy Doolittle's piloting skill to the utmost in August and September 1932, he nevertheless sent Pratt & Whitney a letter on Shell Petroleum letterhead,

> I wanted to tell you that the Wasp Senior functioned perfectly during the Shell Speed Dashes and the Thompson Trophy Race. I have never flown a sweeter running engine and want to congratulate you and the Pratt & Whitney Company... (Prouty, 1977, pp. 77-81; Doolittle, 1932)

Amelia Earhart owned and flew a Wasp-powered Lockheed Vega; the plane in which she made her last flight in 1937 was a Lockheed 10 E Electra, with two Wasp engines (Blay, 1988, p. 22).

Passenger traffic continued to grow with the increasing comfort and convenience of the airlines' planes and schedules. Advertising in *Aviation* acknowledged the new markets; e.g., one illustration shows over a dozen men and fashionably attired women waiting to board a trimotor, another advertisement touts new materials which "bring valuable refinements in passenger planes," and yet another, showing a chic young woman at ease in her airline seat, simply offers "Latest Upholstery Fabrics for Modern Transportation" (*Aviation*, February 9, 1929, p. 394; April 6, 1929, p. 1136; June 15, 1929, p. 2186).

Passenger traffic still did not generate enough revenue to support the service, however. Government support, in the form of subsidized airmail contracts, was sought and obtained by United and other airline operators. This proved a source of notoriety in 1934, when Senator Hugo L. Black directed an investigation into what seemed inordinate, not to say obscene, profits made by the aviation industry at a time when other sectors of the American economy were suffering (*Hearings*, 1934).

Interdependence, 1920-1940

Both the aviation industry and the federal government were caught in mutual dependence throughout this period. Companies such as Pratt & Whitney Aircraft prospered by employing demonstrated technical excellence together with personal connections in timely fashion.

Civilian designers and manufacturers needed large markets to provide economic support for innovation, while the military saw the importance of a well-developed civilian manufacturing capability long before civil aviation emerged from the barnstorming stage. The industry chafed at the restrictions attendant upon receipt of public money, yet relied on government contracts and subsidies during this period of pioneering growth.

Vertical integration, an effective tool in adapting to the uncertain civilian market, rendered United and others vulnerable to deeply held public anti-trust sentiments. The government could not afford to ignore this, and indeed used these sentiments as a political brake on the degree to which it accommodated the aeronautical industry.

The emergence of a self-sufficient civilian airline industry awaited the development of aircraft which were safe and comfortable enough to attract a large number of passengers, but such development required a sizeable investment in research and innovation. Since the civilian market could not yet support this investment, federal recognition of the national interest prompted long-term economic support. With this stable support, Pratt & Whitney could concentrate on solving the technical problems encountered with increasing demands for higher engine performance.

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