George W. Lewis, NACA Director of Aeronautical Research from 1924 to 1942.

FROM INERTIA TO ACTION

At first the NACA watched European developments in engine technology without full awareness of their implications for American national security. In September 1936, George Lewis [**5**] visited Germany to evaluate reports of recent expansion and decentralization of German aeronautical facilities. He found that research under Adolf Baeumker was being funded and staffed on a grand scale hardly dreamed of in the United States. Baeumker reported directly to Hermann Goering, Hitler's Air Minister, and there seemed to be no limit to the funds available to finance Baeumker's grandiose scheme of aeronautical laboratories. The Germans, he wrote, were contemplating a long-range research program. Its major emphasis was to increase the speeds of airplanes, regardless of the expense.

Lewis pointed out that, prior to Chancellor Adolf Hitler's rise to power, funding for the Deutsche Versuchsanstalt fur Luftfahrt (DVL) at Adlershof near Berlin, the German counterpart of Langley Laboratory, had been limited. Hitler apparently made unlimited funds available to Baeumker. For military reasons, the Germans had decided not to concentrate all their aeronautical research and development at one location; therefore, Adlershof was to be supplemented by two additional stations, one entirely devoted to engine research at Stuttgart, the other for more fundamental aerodynamic research at Braunschweig. A large and elaborate pressure-type wind tunnel had been completed at the University of Goettingen under the direction of the famous aerodynamicist Ludwig Prandt. Lewis noted the extensive facilities for aircraft engine research and testing at the DVL, in particular, altitude test facilities for both air-cooled and liquid-cooled engines. Research in fuels and lubricants, stimulated by the impending acute shortages of fuel in Germany, took place in a special room containing an array of single-cylinder test engines. He pointed out, slightly disparagingly, that the electric dynamometers and other gadgets made him wonder whether he was. "In an engine-testing laboratory or a small edition of the Licke observatory".[9] Although Lewis considered NACA facilities superior to those in Germany, the number of personnel and the advanced level of their training worried him. He estimated that in the near future there would be about 1000 employees engaged in aeronautical research at four separate sites compared to a mere 350 at Langley Laboratory. Even more serious was the superior technical training of German scientists and engineers. Graduate engineering education in the United States would become increasingly important as the theoretical demands of aeronautical engineering increased.

Lewis's report on his 1936 trip to Germany was the first intimation that the NACAs Langley Laboratory might be inadequate for the nation's future research needs, In response to Lewis's report, the NACA set up a special committee under General Oscar Westover, then Chief of the Army Air Corps. It took three years for the committee to address the question of the relation of the NACA to defense of the United States in the event of war. [10]

Meanwhile, military aeronautical technology in Germany was rapidly overtaking that of the United States. As early as 1937 John Jay Ide, the NACAs technical assistant in Europe, warned of the results of German advances. He reported that Germany was producing extraordinary airplanes and engines that had enabled them, with their ally Italy, to set a "holocaust of records". Ide noted that in the development of aircraft engines there had been no spectacular breakthroughs. Steady incremental improvements were nevertheless pushing European engine development to new heights. Both England and Germany had developed liquid-cooled engines with two-speed superchargers to power fighter aircraft. By 1939 Ide had concluded that, so great was the German emphasis on the development of new technology, the next war would be a "war of workshops". The country able to develop the most advanced aircraft would have a strategic advantage. Ide emphasized that for the Europeans it was *speed* above all that was important. The [**6**] Germans had airplanes that could reach speeds of over 400 miles per hour. The fastest planes, he noted, all had liquid-cooled engines.[11]

In letters to the NACA from England, Charles Lindbergh also described European advances in aircraft propulsion. In his letter of August 1937 he expressed mild concern: "As Dr. Ames said in one of his letters, American aviation is, generally speaking, still well ahead of European aviation. However, I believe we must work very much harder in the future in order to maintain our leadership".[12] Lindbergh was especially impressed by the new facilities at the Junkers and Heinkel aircraft companies in Germany, built at government expense. The British also seemed to be pushing ahead of the United States with new engine types. He noted that Europeans were developing rockets and urged the NACA to begin work in rocket development. He recommended that the NACA contact America's lone rocket pioneer, Robert Goddard, about future cooperation. Unlike Wernher von Braun, the architect of the Nazi's fearsome V-2 rocket who closely scrutinized Goddard's papers, the NACA considered Goddard too visionary.[13]

As Europe moved closer to war, Lindbergh's increased sense of urgency drove him home from Europe in 1939. He went straight from his steamship to a meeting with the future chief of the Army Air Corps, Henry Harley Arnold. Arnold recalled, "Nobody gave us much useful information about Hitler's air force until Lindbergh came home in 1939". [14] After the slow-moving Westover committee recommended a second laboratory for research in aerodynamics and aircraft structures (the future Ames Aeronautical Laboratory in Sunnyvale, Calif.) Lindbergh agreed to chair a Special Committee on Aeronautical Research Facilities. Lindbergh was convinced that the United States needed better aircraft engines." [15] As Hitler's September *Blitzkreig* swept through Poland, Lindbergh's committee urgently recommended the construction of an engine research laboratory in a location accessible to the engine companies. Lindbergh was convinced that the development of liquid-cooled engines was not receiving sufficient attention in the United States.

Other high-level aviation experts shared his view. The periodical *Science* warned that the nation needed research facilities above all because of "the superiority of foreign liquid-cooled engines."[16]

The recognition of the gravity of the engine situation coincided with the strengthening of the leadership of the NACA. The same day that Lindbergh made his recommendations, the NACA elected Vannevar Bush to take charge of forging a wartime research program. A former Dean of Engineering and Vice President of the Massachusetts Institute of Technology, Bush appreciated the value of research. He greatly admired the NACA and looked upon its organization as a model for the mobilization of science. Known as both a scientist and a hard-headed practical engineer, he considered the best engineering to be applied science. For him, the NACA exemplified this ideal.[17]

The NACA elected George Mead, former Vice President of United Aircraft and one of the country's most respected engine designers, Vice Chairman. Shortly afterwards he replaced Bush as head of the Power Plants Committee. He would oversee the design of the new NACA Aircraft Engine Research Laboratory in Cleveland, Ohio. Mead's experience with engine development was long and impressive. From engineer-in-charge of the Army's Power Plants Laboratory in Dayton, Ohio, Mead had become chief engineer for the Wright Aeronautical Corporation. In 1925 he left Wright with Frederick B. Rentschler to found the Pratt & Whitney Company in East Hartford, Conn. Mead's engineering genius was responsible for the successful design of the Wasp and Hornet engines, which turned the fledgling company into a formidable competitor of Wright Aeronautical.[18]

[**7**] The defection of some of Wright Aeronautical's most able staff and the subsequent success of Pratt & Whitney had created a bitter rivalry between the two companies in the commercial development of air-cooled engines. Neither company, however, had taken great interest in the development of engines with liquid cooling, Profits for both companies clearly lay in the continued development of the air-cooled, or radial, engine. In a country with vast distances to cover, the air-cooled engine was more rugged, lighter, and consumed less fuel than its liquid-cooled counterpart. It could be maintained easily, and it did not require a radiator, which might be punctured by enemy fire. To increase the power of the radial engine during World War II, up to four additional banks of cylinders were added behind the initial nine, making the engine more difficult to cool.

By the early 1930s the military concluded that for strategic reasons the United States should not depend exclusively on air-cooled engines, despite their dominance of both the military and commercial markets. For military applications, where speed and high altitude were important, the liquid-cooled engine had great advantages. The sleek in-line arrangement of its cylinders meant that the engine could be placed in the wings, rather than up front in the fuselage behind the propeller, where the bulky engine could obstruct the vision of the pilot. The Army supported the development of liquid-cooled engines by several companies. However, by 1940 only the Allison V-1710, made by the Allison Division of General Motors, was ready to be mass-produced for fighter aircraft. Before 1943 the Allison was inferior to comparable European liquid-cooled engines like the British Merlin, but to power fighter aircraft it was superior to the best air-cooled engines produced by Wright Aeronautical and Pratt & Whitney. [19]

Among the executives of the two established engine companies, only George Mead had taken a strong interest in the development of a liquid-cooled engine. In 1937 he returned from a trip to England impressed with a British liquid-cooled engine with an H-type sleeve valve. He urged Pratt & Whitney to make the investment in the new engine type.[20] The corporate leadership of the company, however, was cool to the idea, although design studies were initiated. In June 1939 the company decided to concentrate its efforts on the development of superior air-cooled engines. This seems to have precipitated Mead's resignation, making him available to serve the NACA on the eve of America's entry into World War II. One of his first accomplishments was to reform and,strengthen the Power Plants Committee. He insisted that all three engine companies, Wright Aeronautical, Pratt & Whitney, and Allison, as well as the petroleum industry have representation. [21]

The job of the Power Plants Committee was to figure out how to encourage innovations in engine design. The first step toward this goal was to implement as quickly as possible Lindbergh's recommendation for the new federally funded engine research laboratory. Mead formed a Special Committee on New Engine Research Facilities to hammer out the design of the proposed laboratory. Gaylord W. Newton represented the Civil Aeronautics Administration, Commander Rico Botta, the Navy, and Major E. R. Page, the Army Air Corps. Carlton Kemper, head of the Engine Research Division at the Langley Laboratory, and George Lewis were the NACA members. Although membership was balanced among the engine companies the military, and the NACA, the engine companies, wielded considerable power. In addition to Mead, Ronald Hazen, President of the Allison Company, and Arthur Nutt, Vice President of Engineering for Wright Aeronautical, were key members.

Sam D. Heron, an executive of the Ethyl Corporation in Detroit, Mich., served as a valuable link between the NACA and the petroleum industry. After work on the design of air-cooled [**8**] cylinders at the Royal Aircraft Factory in England, Heron had pioneered the development of sodium-cooled engine valves for the Army Air Corps at Wright Field in Dayton, Ohio. Mead called on Heron to persuade the engine laboratory planners to include a fuels and lubricants facility. Heron emphasized that, despite the large amount of research being carried on by the petroleum industry, "it was impossible to do too much work toward improving fuels". Heron presented a detailed proposal for an elaborate facility that was adopted without opposition. [22] This commitment to fuels research would some day bear fruit in the future laboratory's role in the development of liquid hydrogen as a high-energy rocket fuel.

It was decided immediately that research on both liquid- and air-cooled engines would be conducted at the new NACA Aircraft Engine Research Laboratory. Testing would be carried out on models and full-scale engines, as well as on the various components, such as superchargers, carburetors, instruments, and both fuel injection and fuel ignition systems. To implement the basic plan of the engine laboratory, the NACA formed a design group at Langley that consisted of a nucleus of 15 seasoned men and II enthusiastic recent engineering graduates. The group worked feverishly at Langley under Smith DeFrance, who was responsible for the early designs for both the new aircraft structures laboratory at Sunnyvale, Calif., and the new engine laboratory. When DeFrance was sent to Sunnyvale, Ernest G. Whitney took over. While DeFrance took with him the problem of the aerodynamic design of the engine laboratory's wind tunnels, Whitney faced the formidable task of coordinating all the elements in the complex design, as well as supervising the early construction of the new laboratory.[23]

An item that raised considerable debate among the laboratory planners was the decision to include a wind tunnel. Only three facilities existed in the United States for attitude testing of aircraft engines: the Bureau of Standards, the Naval Aircraft Factory in Philadelphia, Penn., and the Army's Power Plants Laboratory at Wright Field. None of the three could test engines at sufficiently high altitudes. George Mead argued strongly in favor of a wind tunnel. He was critical of the limited facilities for engine testing at Langley.[24]

The inclusion of a wind tunnel in the plan became a bone of contention because wind tunnel tests could be construed as development, The NACA did not approve of "mingling research and development work in the same organization," but how this principle applied to engine research was not clear. [25] The established engine companies, Pratt & Whitney and Wright Aeronautical, argued that an altitude wind tunnel would allow the NACA to compete with industry in engine development, but the Allison Division of General Motors supported the wind tunnel because it needed help in developing its liquid-cooled engine. The two established companies feared that more vigorous competition from a wider field of engine companies would affect their ability to continue to reap large profits on commercial engines. The issue of the relationship of the new laboratory to industry remained one of the thorny problems left to be tackled once peace was restored. The nation, however, could no longer afford to leave engine development exclusively in the hands of industry.

At the January 1940 meeting of his planning committee, Mead called for the opinion of Frank W Caldwell, a man he respected for his expertise in developing the variable pitch propeller for Hamilton-Standard Propellors Company. Caldwell argued strongly in favor of an altitude wind tunnel to study the influence of engine vibration on the propeller. After his presentation, Mead's committee reached the long-sought consensus that an altitude wind tunnel, capable of testing engines up to 3000 horsepower, be included in the plan. Caldwell also suggested that the engine laboratory include a propeller research laboratory, a proposal that was also adopted. George Mead [**9**] submitted the final report of his committee to Vannevar Bush on January 23, 1940. It stated that "the proposed facilities are urgently needed and are vital to both the national defense and to the future success of our commercial aviation".[26]

The role of the new government engine research laboratory was carefully described by Vannevar Bush when he testified before the Subcommittee of the Committee on Appropriations in the U.S. House of Representatives. Bush asked for an appropriation of $8,400,000. He stressed that the engine research facilities at Langley were extremely limited, that private industry did not conduct the necessary research, and that government would not compete with industry. Both General Arnold, Chief of the Army Air Corps, and Admiral Towers, Chief of the Bureau of Aeronautics of the Navy Department, strongly supported the proposed legislation. [27] Called on to describe the nature of the proposed laboratory in detail, George Lewis estimated that it would have a staff of 220 and an annual operating cost of $650,000. The single most expensive item, the altitude wind tunnel, Lewis called "very, very desirable". Such a facility did not exist anywhere in the world. He estimated that, at a simulated altitude of 30,000 feet, the speed of the wind tunnel would be 490 miles per hour. In the proposed tunnel the engine, supercharger, and propeller could be studied at full scale both separately and as a unit, so that months of flight testing could be eliminated.

A congressman's question gave Lewis the opportunity to emphasize the importance of government research and the void that it was intended to fill: "There is no governmental research of engines being done in the United States now? It is all done by the private establishments, is it?"

Lewis's response was terse: "There is very little scientific research being done on engines in this country. Private establishments are concerned chiefly with development problems relating to their own engines. The aircraft engine research work that is being done at Langley Field represents the major portion of all fundamental research on aircraft engines in this country".

Lewis continued to be pressed by the congressman: "And that is very limited?"

Lewis replied that, although the Army and Navy had research facilities for engine testing, this was only development work. The Army's Power Plants Laboratory at Wright Field in Dayton, Ohio, and the Navy's Aircraft Factory in Philadelphia, Penn., were used to evaluate engines produced by a particular company to determine whether they met military specifications. This was not fundamental research-the purpose of the new laboratory.[28]

Although Lewis was not asked to define fundamental research, it would have been an appropriate question. Did congressmen understand the difference between fundamental research and development? What could the government do that industry would not, or could not, do? It was clear that the engine companies were not happy that such vast sums would go to a new government laboratory. In early June, in a final attempt to prevent the authorization of government engine research, they proposed that, instead of spending $8,400,000 for the new laboratory, the government give each company $3 million to do its own research. The NACA responded by memo that the essence of a government research laboratory was to tackle problems common to the entire industry and to see that the information was equally accessible to all companies in a given field. This is what the NACA called fundamental research. Competition prevented the exchange of information, so that each company had to work independently "to solve problems common to them all," an unnecessary duplication of research, effort. Moreover, if the engine companies were given money directly, they would focus their research on immediate problems "of perhaps low fundamental significance but of high specific interest to that individual company". Thus, research would be too closely tied to development. Moreover, the NACA memo pointed out, research on components would be neglected, because the engine companies bought these parts [**10**] from other manufacturers. In the NACA's view, the entire aircraft engine deserved equal and impartial scrutiny.[29]

With the forced evacuation of the Allied Forces at Dunkirk and the fall of France in early June 1940, could Great Britain resist invasion? Alarmed by the implications for the national security of the United States and already committed to supplying aircraft to Great Britain, Congress approved the funding for a new NACA aircraft engine research laboratory in June 1940 as part of the First National Defense Appropriations Act.[30] A site for the new laboratory remained to be chosen.

CLEVELAND WINS THE BID

At this point the efforts of the Cleveland Chamber of Commerce moved into high gear. Cleveland's location, industrial base, and particularly the connections and active involvement of Frederick C. Crawford, President of Thompson Products, won the new laboratory for Cleveland. Crawford worked with energy, determination, and tact to make sure that the NACA chose Cleveland. His motivation was simple. The new laboratory would be good for his company. Thompson Products made automotive and aircraft engine parts and was just beginning its wartime expansion. [Thompson Products became Thompson-Ramo-Wooldridge Corporation (TRW) in 1958.]

Crawford's behind-the-scenes action began in 1939, as soon as he heard that the NACA was considering a second laboratory to supplement or possibly replace the one at Langley. He asked Clifford Gildersleeve, the Industrial Commissioner on the staff of the Chamber of Commerce, to prepare an invitation to the NACA in August.

Selling Cleveland was not new to Gildersleeve. His job was to attract new industries to the city, and he was well aware of the opportunities for industrial expansion created by the war in Europe. With the infusion of federal funds for new plants and the modernization of old ones already under way, a large government research facility would make the city all the more attractive to industry. [31]

The invitation that Gildersleeve prepared for the NACA described Cleveland in alluring terms typical of Chamber of Commerce brochures. Located in the nation's industrial heart, the city stood as the industrial nexus between the Pennsylvania coal fields and the iron of the Mesabi Range in Minnesota. The great coal-fired open hearth furnaces of the mills in the Flats along the Cuyahoga River processed the iron ore into steel. Gildersleeve's invitation pointed out that half of the population of the United States and more than half of the country's manufacturing were located within 500 miles of the city. Cleveland was also a hub of transportation. The airport handled a daily average of 100 planes, making it among the busiest airports in the country. In addition to highway connections, six major railroads served Cleveland, and the Great Lakes were used by industries like Republic Steel to transport iron ore cheaply. Electric power in Cleveland, supplied by the Cleveland Electric Illuminating Company, was "plentiful and dependable". In addition, Cleveland owned and maintained its own water system.[32] What the invitation did not state was that the city, still recovering from the Depression, desperately needed jobs for its workers. The city's reputation for tightly organized unions made new industries reluctant to locate in Cleveland. To cope with 87,000 poor relief cases, the city received federal assistance, but it still faced a large prior relief deficit of over $1 million.[33]

Clevelanders, however, loved aviation. The city's sponsorship of the enormously successful National Air Races had first brought Crawford into contact with the NACA through his association [**11**] with John Victory. Victory had visited Cleveland frequently as one of the officials of the National Air Race Association Committee, Crawford's company awarded the coveted Thompson Trophy each year, and his enthusiasm for aviation was well known. Although the manufacture of parts for automobile engines was the major business of Thompson Products, the company also sold sodium-cooled valves to the two giants in the aircraft engine field, Wright Aeronautical and Pratt & Whitney, a business that flourished during World War I with the production of valves for the Liberty engine.

Other Cleveland companies were in the parts business. In 1940 Cleveland boasted no less than 80 to 90 companies "catering directly to aviation".[34] Eaton Industries also produced sodium-cooled valves, and Cleveland Pneumatic had pioneered the development of pneumatic landing gears. With a new plant for Wright Aeronautical's engines under construction outside Cincinnati, Crawford saw that Cleveland aircraft parts industries could anticipate substantial expansion as a result of the war in Europe. What could be more appropriate for the city than a major research laboratory for aircraft engines?

The city's identification with both the romance and commercial potential of aviation had begun during World War I, when a group of Cleveland investors persuaded a gifted, if somewhat eccentric, aircraft designer, Glen L. Martin, to locate his aircraft company in Cleveland. During its years in Cleveland, Martin's company produced the important Martin GMB-1 bomber and attracted some of the most talented airplane designers in the country: Dutch Kindelberger, Lawrence Bell, and Donald Douglas. When Martin moved his company to Baltimore in 1929, he left as his legacy to the city his role in spearheading the development of Cleveland's municipal airport.[35]

The large size and careful design of Cleveland's airport made it a natural site for the National Air Races. The Air Races brought Crawford and the NACA together. Held in Cleveland 8 of 11 years between 1929 and World War II, the races provided the opportunity to push beyond the existing speeds of aircraft. Prominent Cleveland industrialists like Crawford and Lewis W. Greve, President of Cleveland Pneumatic, supported them enthusiastically. Many of the engine improvements first demonstrated on racing aircraft were later adopted by the aircraft engine companies.[36] What could be more natural than a new federal laboratory to continue to encourage engine innovation?

Cleveland lost out to Sunnyvale, Calif., as the location for the Ames Aeronautical Research Laboratory because Sunnyvale was close to the California aircraft industry which exercised its political clout on Capitol Hill. Nevertheless, when Congress authorized funds for an aircraft engine laboratory, Cleveland was ready to push for its selection. Gildersleeve and Walter I. Beam, the Executive Secretary of the Chamber of Commerce, had already convinced Cleveland's local officials of the desirability of the city as a site for a government research laboratory. As an incentive, the city had agreed to make nearly 200 acres of land next to the Cleveland Airport available for $1 an acre, as well as raise $550,000 locally for power facilities.[37]

The NACA was determined that the competition for the site for the new engine laboratory be properly and impartially administered. After the engine laboratory was funded, the NACA selected a blue ribbon committee, chaired by Vannevar Bush, to recommend a site. [38] The committee sent letters to all interested congressmen, Chambers of Commerce, and other interested individuals stating the requirements to enter the competition. Because the new laboratory would require facilities for flight-testing, the city had to be able to make available title to 100 acres either on or adjoining an airport owned by a municipality or already owned by the federal government.

[**12**]

George Lewis explains the Plan for the new engine research laboratory to top NACA staff.

With a large wind tunnel planned, the site also needed adequate power as well as ample water for cooling. The city should be an industrial center, accessible to the engine companies located either on the East Coast or in the Midwest. The site also had to be near "centers of scientific and technical activity". Another factor to be considered was "strategic vulnerability". Since there was a perceived danger that the United States might be attacked on either coast, where the NACA:s other two laboratories were located, there was a general feeling that the Midwest offered the safest location. The NACA used an elaborate point system, originally devised for the Sunnyvale site selection, to judge the contenders for the new engine laboratory.[39]

In July the Cleveland Chamber of Commerce issued a formal bid to the NACA for the new laboratory, responding directly to the list of criteria. The Chamber of Commerce enlisted the support of the local Society of Automotive Engineers to impress the NACA with the city's engineering community. In addition, the presidents of the Case School of Applied Science and Western Reserve University wrote letters that described in glowing terms the excellence of the educational resources of the city.

Cleveland faced stiff competition. Of the 72 sites in 62 cities that submitted bids, 14 cities, offering a total of 20 sites, met the stipulated criteria. A Special Committee on Site Inspection visited the top-ranking cities. The major contenders, as presented at the September meeting of the Bush Committee on Site Selection, were Cleveland, Ohio; Dayton, Ohio; Detroit, Mich.; [**13**] Cincinnati, Ohio, and Aurora, Ill. However, by October, Glenview, near Chicago, took the number one position in the ratings, with Cleveland running second. Officials in Chicago had convinced the NACA that the Chicago area, with its many university and industrial research laboratories, could provide a superior research environment. The drawbacks of the Cleveland site were the unusually high rates for electric power charged by the Cleveland Electric Illuminating Company and the spectator stands for the National Air Races on the proposed site. Would the continued operation of the races interfere with the plans for the new engine laboratory.? Because the Material Division of the Army Air Corps was already located at Wright Field near Dayton, where the Army had its own power plants laboratory for testing engines, the Army urged the NACA to consider the Dayton site. Not surprisingly, Orville Wright, a prominent member of the NACA, put his weight behind his hometown.[40]

Nevertheless, John Victory and Rudolf Gagg, a Wright Aeronautical consultant retained by the NACA, favored Cleveland over the other cities under consideration and were willing, while keeping a public stance of impartiality to go out of their way to help Cleveland win the bid. This was no doubt due to the "personal relationships of long standing" between Frederick Crawford and the NACA.[41] Not only had Crawford "gone to Washington for a number of conferences, had and the NACA conferred with people in New York, and had given up much time to Cleveland's effort to obtain the laboratory," but he had also taken a personal hand in the negotiations between the NACA and the Cleveland Electric Illuminating Company. In order for the Illuminating Company to avoid the capital investment involved in building new generating plants to supply the proposed engine laboratory, Crawford came up with the idea that the company could offer reduced rates if the NACA were willing to run its large testing facilities at night.[42] This was a shrewd move on the part of Crawford, although at first the conservative Illuminating Company resisted the proposed arrangement.

To discuss the problem of the power rates and the city's intentions as far as the National Air Races were concerned, Victory, Gagg, and Russell Robinson visited Cleveland on October 14. Their trip had an extremely favorable outcome. As Victory recalled, "one fly in the ointment" was the skepticism of Evan

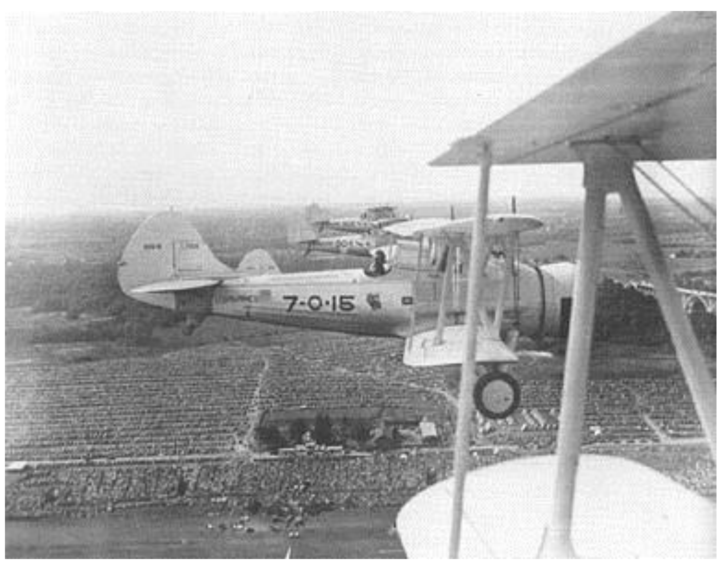
Crawford, the President of the Illuminating Company. Evan Crawford doubted that the wind tunnel could be run on an off-peak basis. Victory remembered:

The electrical rates he offered were considered prohibitive-Into this breach stepped Fred Crawford, just in time to prevent the collapse of negotiations. I shall never forget the final scene in Evan Crawford's office when he yielded and then promised that, if Cleveland were selected, his company would "ooze cooperation from every pore". [43]

The Illuminating Company agreed to a substantial reduction in the monthly electric rates. From a minimum annual charge of $120,000 in the original proposal, the power company agreed to a minimum charge of $50,000. This clinched the choice for Cleveland. In addition to the concessions of the electric company, Major John Berry, superintendent of the airport, reported that the park commissioners had agreed to offer part of the park adjoining the airport to the NACA. This would create a buffer around the new laboratory of a mile on every side. Crawford indicated the likelihood that the operation of Cleveland's National Air Races would be suspended and the willingness of the National Air Race Association Committee to have the stands removed.[44]

The selection of Cleveland as the site was formally announced to the press on November 25, 1940 by Vannevar Bush. After political maneuvers to avoid objections over whether the municipal government could turn over the land at less than the fair price, the Mayor of the City of Cleveland, Harold H. Burton, sold 200 acres of land for $500 to the federal government. The NACA was granted the right to use the airport free of charge, and it was agreed that neither the airport nor the NACA would erect buildings that would interfere with the operations of the other. If the laboratory's activities ceased, the land would revert to the City of Cleveland.

[**14**]



A squadron of U.S. Marine planes flies over the site of the future Aircraft Engine Research Laboratory during the National Air Races, 1935. The Brookpark Road Bridge is at the right.

Soon the stands for the spectators would be pulled down to make way for the new buildings of the NACA Aircraft Engine Research Laboratory. Roscoe Turner carried off the Thompson Trophy for the last time in 1939. The air races had kept interest in aviation alive through the Depression. They had contributed to increasing the speeds of aircraft through the tinkering of talented mechanics. With the most advanced engine research facilities the country could muster about to be built at the edge of the airport, engine innovation would become more rational and systematic. People with professional training in engineering and science would take over from the racing buffs the job of increasing the speed of aircraft. Nevertheless, the role the laboratory would play in engine innovation was not entirely clear. Over the objections of the engine companies, which feared that government research might interfere with healthy competition, Congress had funded the NACA's new engine laboratory. Vannevar Bush and George Lewis had used their considerable prestige to assure the Congress that fundamental research would foster innovation. They argued that the NACA would tackle engine problems common to the entire industry. The development of new engine prototypes would remain the province of the engine companies. Yet the construction of a wind tunnel belied these assurances. Testing full-scale engines in a wind tunnel [**15**] strained the definition of fundamental research. However, with the impending war, there was no time to debate the fine points of the respective boundaries of fundamental research and development.

As he stood in the frigid wind on that January for the ground-breaking ceremony, Crawford may have reflected that the heyday of the National Air Races was about to end. Military airplanes had reached speeds beyond those of any plane ever entered in the air races. These new machines of war had out-raced the races."[45]

Notes

1. "Lewis's talk at ground-breaking ceremonies," 23 January 1941, NASA Lewis Records, 298/110-411.

2. A British technical mission, headed by Sir Henry Tizard, visited the United States in September 1940. For a general discussion of the mission, see Daniel J. KevIes, The Physicists (New York: Vantage Books, 1979), p. 302-303. Specific reference to the disclosure of British advances in jet propulsion made by Tizard are found in Bush to Arnold, 2 July 1941, 471208, and Papers of H. H. Arnold manuscript Division, Library of Congress. Arnold to Tizard, 4 June 1941, 47/208.

3. Jerome Hunsaker, "Forty Years of Aeronautical Research," Smithsonian Report for 1955, p. 246. For the administrative history of the NACA, see Alex Roland, Model Research: The National Advisory Committee for Aeronautics, NASA SP-4103 (Washington, D.C.: U.S. Government Printing Office, 1985), vol. 1.