PUBLIC LAW 81-415: THE UNITARY WIND TUNNEL PLAN ACT OF 1949 AND THE AIR ENGINEERING DEVELOPMENT CENTER ACT OF 1949[1]

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INTRODUCTION

Displayed in the lobby of Arnold Engineering Development Center's headquarters building is a case crafted from the timbers of the newly fireproofed White House. The case holds the pen with which President Harry Truman signed Public Law 81-415, a single act with two titles: Title I, The Unitary Wind Tunnel Plan Act of 1949, and Title II, the Air Engineering Development Center Act of 1949. My charge for this session was to explain the relationship between Title I and Title II. Perhaps the best way to describe my assignment is in technical terms: A Venn diagram, with Title I on the left side, the intersection, and Title II on the right side. As it turns out, Dr. Hugh L. Dryden, Director of Aeronautical Research, National Advisory Committee for Aeronautics (NACA), directly answered that question in his April 1949 testimony in support of PL 81-415:

> The relationship between title I and title II of the bill which covers the unitary wind tunnel plan and the Air Engineering Development Center are shown by this chart overlapping. In other words, the unitary wind-tunnel plan includes tunnels at universities and at existing laboratories and at the Air Engineering Development Center.
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> The [AEDC] contains two of the supersonic wind tunnels of the unitary plan, and, in addition, an altitude chamber for

[1] Public Law 81-415: Unitary Wind Tunnel Plan Act of 1949 (50 U.S.C. 501-515) and Air Engineering Development Center Act of 1949 (50 U.S.C. 521-524).

> tests of jet power plants under altitude conditions, a runway, housing, and other facilities.
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> I might mention, as the question might come up, that the unitary plan and the [AEDC] started as two separate propositions. There were joined by the Bureau of the Budget at their request because of this overlap.[2]

Having already fulfilled my given task, I am now free to tell the background story of AEDC's conception, gestation, and birth. Since Dr. Dryden also conveniently summarized the nightmarish coordination process that extended from May 1945 to October 1949, I will omit that today but leave it in the longer version of this presentation.

> Some people were convinced that rather large capital investment was required in this country if we were to get up to the position the Germans occupied. They no longer hold that position now, of course, but the Army, Navy, and Air Force had many ideas of what was to be done.
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> Assignments were made as a result of a coordination procedure by which the ideas of all interested groups in Government and industry were considered by panels of the several agencies and reviewed by a [NACA] special panel on supersonic laboratory facilities, and the [NACA]. There were various panels set up, one headed by Dr. Raymond, chief engineer of the Douglas Corp., and one headed by our chairman, Mr. Hunsaker, which made suggestions, which led to a recommendation by the [NACA]. The [NACA] report was forwarded to the Research and Development Board, where it was reviewed by the Aeronautics Committee and the Board, after extensive hearings of expert testimony.
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> The plans were considered by the President's Air Policy Commission and by the Congressional Aviation Policy Board. The [NACA] and the National Military Establishment jointly submitted the approved plan to the Bureau of the Budget, and after review by them, to the Congress.

[2] Subcommittee Hearings on H. R. 3434, to Promote National Defense by Authorizing a Unitary Plan for the Construction of Transonic and Supersonic Wind Tunnel Facilities and the Establishment of an Engineering Development Center, 11 Apr. 1949. Testimony of Dr. Hugh Dryden , pp.. 4058-59; "Short History of Unitary-Wind-Tunnel Plan," no date.

> In the course of this coordination procedure the magnitude has been reduced from more than a billion dollars to about $300,000,000. Now the plan has reached your committee.

Title II of PL 81-415, the enabling legislation for AEDC, is short, fewer than 300 words, but the history it reflects is at the same time an account of America's efforts to counter Germany's widely perceived superiority in aeronautical test facilities at the end of the Second World War. It is a story replete with international intrigue and intense technical and political battles among nations and U.S. government agencies to determine the character and site of AEDC, battles significant enough to bring the President of the United States for AEDC's June 1951 dedication to a site that the German engineer and general Walter Dornberger called "a dull and boresome place far away from all centers of culture."[3]

THE DILEMMA

The "General Statement of Purpose" for PL 81-415 clearly stated why the United States needed this legislation:

> The purpose of this bill is to authorize the construction of wind tunnels and other experimental and testing facilities suitable for research, development, and evaluation in the field of transonic and supersonic aeronautics. This field, covering as it does the range of very high-speed flight – both by aircraft and guided missiles – promises to be of the utmost importance because of the steady trend toward higher speed aerial vehicles in the development of newer and more effective types of military aircraft and missiles.[4]

[3] Walter Dornberger, "Incentives within the AEDC," Wright Field, 21 February 1949.
[4] Senate Report No. 443, 2 June 1949; House Report No. 1376, 4 Oct. 1949; Conference Report No. 1451, 17 Oct. 1949. The House Report repeats in substance the Senate Report. The Conference report, also set out, outlines changes to the bill accepted by the Conference. House Report No. 1376. Hereafter "Legislative History," p. 2298.

As the U.S. answered the German wake-up call in Europe, the National Military Establishment, NACA, industry, and other interested parties began to assess this country's aeronautical capabilities. Our near loss of the war signaled that the U.S. needed to development new facilities that could handle the special challenges of the jet engine, because mass production would not win the next conflict.

As early as 1938 General Henry "Hap" Arnold had sought to develop advanced facilities at Wright Field, then the principal technical center for the Army Air Forces (AAF). The AAF farmed out its research and testing to other agencies, a situation that the General found untenable, because he wanted the AAF to maintain control over the aircraft development process. Arnold proposed major modifications at Wright Field: a large propulsion wind tunnel with high power and mass flows for the Power Plant Laboratory, a wind tunnel with high-altitude capabilities for testing gas turbine-driven propellers for the Propeller Laboratory, and a new supersonic 20-foot wind tunnel that required a 40,000 horsepower compressor and turbine component test facility for the Aircraft Laboratory.

Needless to say, such a proposal provoked objections from other agencies, including NACA. NACA's director, Dr. George Lewis, in fact offered to build the tunnel, engaging Theodore von Karman as a consultant, and operate it for the Air Force, but von Karman had already agreed to be General Arnold's consultant. "That settled the matter," Frank Wattendorf said. Von Karman asked Wattendorf, who had worked closely with

him both in prewar Germany and at the California Institute of Technology, to help with the aerodynamic design of the proposed 20-foot wind tunnel.[5]

Harvard Professor Lionel Marks had led a committee to investigate the feasibility of gas turbine propulsion for aircraft applications. In its report the committee concluded that it was not, the report published at roughly the same time that – unknown to the Marks group -- Hans von Ohain's turbo jet engine made its first successful flight in Germany. When General Arnold witnessed Frank Whittle's turbojet in 1941 test flights, he immediately ordered the concept brought to the U.S. for further development.

Since the ground rules for U.S. aircraft development during World War II had been to win the war with mass production of what this country already had, research into jet propulsion had not been a national priority. Moreover, the American engine industry's production lines devoted three shifts per day to piston engines. General Arnold therefore arranged with the British to have the Whittle engine manufactured in the United States but, in order not the upset the aeronautical engine industry, he directed General Electric to build the engine and Bell Aircraft to build the airplane.[6] The GE engine flew at Muroc in 1942.

Air Force scientific and technical intelligence was, of course, a major U.S. wartime objective. By 1943 troops sent captured German and Japanese aircraft to Wright Field for assessment.[7]

> In November 1944, General Arnold directed that items of captured enemy equipment be collected methodically so technical experts could study the equipment. At Wright

[5]Speech, Frank L. Wattendorf, "AEDC Early Planning," 26 Apr. 1968. Just prior to delivering this speech, Wattendorf retired from NATO's Advisory Group for Aeronautical Research and Development (AGARD), having served as its director since 1952 and vice chairman since the death of Theodore von Karman in 1963.
[6] Wattendorf, "AEDC Early Planning."
[7] "Air Technical Intelligence History," **https://www.asc.af.mil/naic/history/sandtihist.html**

> Field, the Technical Data Laboratory worked with the other laboratories to develop a "wish list" of German equipment they would like to have for technological study and exploitation. Colonel Donald L. Putt was in charge of the overall collection effort known as Project Lusty, and General Carl "Tooey" Spaatz, the Commanding General of U.S. Strategic Air Forces in Europe, picked Watson for the assignment. General Watson's official travel orders allowed him to: Examine or remove any captured aircraft or equipment, carry a camera and photograph any captured equipment, travel anywhere in the Allied Forces occupied zone.[8]

Wattendorf later said about the capture and analysis of a V-1 (the so-called "buzz bomb") at Wright Field that "this first wind tunnel test of a novel jet-propelled device reinforced the implications of the coming era of jet propulsion, and the laboratories intensified their planning."[9] Wright Field clearly had a dilemma; it was simply not equipped to handle the kind of power requirements, not to mention physical space, that the proposed modifications and construction of its laboratories would entail.

In the legislative history for PL-815 Congress summarized the testimony of numerous experts on this matter:

> American aeronautical research has been shown to have lagged dangerously behind the German advances in the fields of jet propulsion and high-speed flight prior to and during World War II. The groups referred to above have already taken full cognizance of this situation and have made recommendations for appropriate corrective steps. Some of these recommendations were made as long as 2 and 3 years ago; yet little, if anything, has been done during the intervening 2 or 3 years since these recommendations were made to expedite their implementation.
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> The Congress would be derelict in its duty to provide adequately for the national defense if it failed to recognize

[8] National Air Intelligence Center (NAIC) Historian, Heritage Series, "Major General Harold E. Watson: Intelligence Pioneer, Air Force Warrior." Rev. ed., May 1995.
http://www.asc.wpafb.af.mil/naic/history/watson.html
[9] Wattendorf, "Early Planning."

> that some of the very same conditions which previously led to our taking second place in the race for more advanced aeronautical weapons may still be present today and that the existence of such conditions can lead to a repetition of our earlier experience – possibly with far more disastrous consequences.
>
> It is not enough for the Congress merely to bestow money liberally upon any and all comers who apply for funds in the name of "research and development" and thereafter wash its hands of this problem; nor can the Congress relax in the comfortable assurance that aeronautical research and development are entrusted to the NACA, an agency composed of recognized experts in the field, or to the aeronautical industry which normally develops and produces newer and better types of aircraft, or to the Air Force and Navy upon whom rests the responsibility for the conduct of aerial warfare. It is imperative that the Congress recognize that these very same responsibilities were vested in the identical agencies – all of them composed of experts – prior to and during World War II; yet that fact did not prevent our drifting dangerously far behind the enemy in the more advanced fields of aeronautical research and development, as exemplified by German progress with jet aircraft, V-weapons and similar types of rockets and guided missiles.
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> To state the foregoing facts is not to imply any unwarranted or harsh criticisms of the agencies or groups mentioned above; to fail to draw attention to these facts, however, would be inexcusable negligence on the part of the committee and would constitute a blind refusal to recognize and profit by the mistakes of the past – mistakes, the more dangerous potential effects of which, we were fortunate enough to escape the last time.[10]

General Franklin O. Carroll, Chief, Experimental Engineering Section, Wright Field from 1939-44 had a major headache: How to reconcile Wright Field's limited potential for expansion with the clearly identified requirement for facilities that could test high-speed aircraft. General Carroll appointed a technical survey team from Wright Field to the European theater. The team consisted of a senior member from each of the

laboratories, of which Wattendorf was one. At the same time von Karman asked Wattendorf to serve on the Army Air Force Scientific Advisory Group (SAG), with the broader objective of advising General Arnold on future scientific and technical potential.[11] Wattendorf, Hugh Dryden, and H. S. Tsien inspected a tunnel at Oetztal, a tunnel that was to shape the future AEDC. Wattendorf described what they found:

> The site of the project is near the confluence of the Inn and Oetz Rivers in the Austrian Tyrol about 35 kilometers west of Innsbruck. This location is particularly suited for hydraulic power, furnished by a drop of 500 meters from the Stuibenbach River. The water available is maintained the year around by snow and glaciers from the nearby Oetztal Alps….The power is furnished by two Pelton turbines delivering 50,000 HP each at 220 rpm, directly connected to two counter rotating fans of 15 meters diameter. The first fan has 14 blades; the second fan has 12 blades. The fan blades are constructed of steel sheets wrapped around a central tubular spar and box beam, and welded at the trailing edge.[12]

In addition to the Oeztal tunnel the SAG examined a jet engine test facility in full operation at the Bavarian Motor Works plant in Munich and, at Kochel, south of Munich, a one-meter by one-meter hypersonic battery of tunnels capable of operations through Mach 10.[13]

The unexpected death of Wattendorf's father interrupted his work in Europe, and he used the time on his C-54 flight to the U.S. to compose a memorandum to General Carroll. Drawing on his experience with Wright Field's power issues and his recent exposure to the German facilities, Wattendorf proposed a new Air Force research and development center that ultimately became AEDC, though in somewhat different form.

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[10] "Legislative History," pp. 2300-01.
[11] Wattendorf, "AEDC Early Planning."
[12] Frank L. Wattendorf, "Oetztal Wind Tunnel," *Army Air Forces Technical Report* no. 5240, 13 Jul 1945.

Citing the future prospects of high-speed jet aircraft and the associated need for research and test facilities for aerodynamics, propulsion systems, and components, Wattendorf compared the facilities he had just seen in Germany with similar facilities in the U. S. German facilities were

> more ambitious and forward looking than our own….There was no indication of the superiority of German engineers over United States engineers as individuals; rather, the improvements were due to more forward looking directives and freer purse strings for engineering and research matters….The scope of the German plans make it essential that our own plans be certainly not less ambitious in the light of our future security. It is recommended that consideration and study be given to the establishment of a new Air Forces Research and Development Center….This establishment should be located near a source of large power, for instance in the Boulder Dam or Grand Coulee Dam regions.[14]

Wattendorf proposed six elements that would serve as the foundation of the new center:

Item 1: A 20-30 foot wind tunnel for throat speeds up to M 1.0 for complete airplane models, full size nacelles, and propulsion systems. Simple straightforward construction with air exchanger is recommended. Utilization of parts and equipment from the Oetztal wind tunnel should be considered. This project would utilize over 100,000 H.P.

Item 2: A 20-30 foot wind tunnel, evacuated and refrigerated, for speeds up to M = 1. This tunnel would be used primarily for propulsive system and propeller development and testing. Such a tunnel would involve about 160,000 H.P.

Item 3: An 8-12 foot wind tunnel for Mach numbers up to approximately 3. The purpose of this tunnel would be development and testing of supersonic aircraft and missiles, together with propulsive systems such as ram jets.

Item 4: A supersonic wind tunnel for very high Mach numbers up to 10 primarily for the development of high altitude rocket propelled aircraft and missiles. It is recommended that utilization of parts and equipment from the 76,000 H.P. Kochel supersonic tunnel be considered. This laboratory would require about 100,000 H.P. for drive, cooling, and accessory equipment.

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[13] Frank L. Wattendorf, Scientific Advisory Group, "Reports on Selected Topics of German and Swiss Aeronautical Developments," n.d.

[14] Memorandum, Frank L.Wattendorf, to Gen. F. L. Carroll, Chief, Engineering Division, AMC, subj: "Proposal for a New Air Forces Development Center," 19 June 1945

Item 5: A components laboratory for developing large compressors, turbines, and component parts of gas turbines and jet engines. This project should be set up around 75,000 H.P.

Item 6: Supporting facilities to enable development of a supersonic aircraft or missile as an integrated whole.

Embedded in this concept was a topographic requirement – a hydroelectric fall – that not only precluded Wright Field as a site but also severely limited the number of appropriate locations. Both Oetztal and Kochel were under construction in the Bavarian Alps, so the area around the Boulder Dam or the Grand Coulee Dam were logical potential sites.

Implicitly embedded in the proposal to re-erect German equipment from Oetztal, Kochel, and the Bavarian Motor Works was the assumption that German scientists and engineers would engage in both the construction and the operation of the relocated materiel. In his book *Science, Technology, and Reparations* John Gimbel addressed in detail the Paperclip saga, which he termed "intellectual reparations."[15] The Joint Chiefs of Staff adopted Project Overcast – the earlier code name – in July 1945, just one month after Wattendorf wrote his memo.[16]

Also implicitly embedded in Wattendorf's proposal was the assumption that the process for re-erecting the German facilities could save time and money by circumventing the requirement for enabling legislation. The Office of Military Government for Germany's (OMGUS) Economics Division in October 1945 sought to end the removal of technical equipment from Germany "pending the allocation of

[15] John Gimbel, *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany* (Stanford, CA: Stanford University Press, 1990), p. 40.
[16] Gimbel, p. 37.

Reparations to the United States," but the Armed Forces Division of OMGUS suggested that wind tunnels be exempt from the proposed restriction.[17]

Therefore, when Wattendorf returned to Germany, he had two further missions for the Air Force: to look for significant German facilities or equipment that might be appropriated for the proposed AEDC and to list the names of German scientists who might be useful in the future design and operation of AEDC. Several of these scientists eventually worked in the laboratories at Wright Field, and some came on loan to Sverdrup and Parcel for the preliminary engineering studies on the center.

Oetztal

Meanwhile, the status of the Oetztal tunnel had changed. From June 1945 on the SAG had proposed to use only the tunnel's drive system, balance, and associated equipment. The plan was to build a new tunnel shell, improving its design as they did. But when he returned to Europe Wattendorf found the Oetztal site not in the U.S. zone but in the French, as a result of Allied rezoning agreements. Individual components of the tunnel, including balances and fans, were in any case not on site but in the plants of the various manufacturers.[18]

In his technical report Wattendorf had described the various contractors for the components, so in early October 1945 Wattendorf visited the Voith Company in Heidenheim, where the Pelton wheels and drive system components had been manufactured.[19] There he encountered what he called "the mystery of the freight

[17] OMGUS, Economics Division, [draft] "Amendment to Directive re Administration of Military Government in the U.S. zone in Germany," Oct. 1945, as cited in Gimbel, p. 115.
[18] Wattendorf, Report No. 5240, 13 Jul 45; Wattendorf, "Historical Aspects of the Oetztal (Modane) Wind Tunnel," 22 Oct. 1981.
[19] Wattendorf, Report No. 5240.

shipments."[20] He described the apparently routine request to load "scrap steel" – actually parts of the Oetztal tunnel – into freight cars destined for Stuttgart, and when he arrived in Stuttgart he found more than a dozen freight cars filled with most of the drive system, including fan blades and associated parts. The cars were scheduled to leave at midnight for Mainz, which lay in the French zone. Wattendorf's solution was to change the manifest from its destination "Mainz" to "Bremerhaven," in the U.S. zone. for later shipment to an Army Air Forces Collection storage base at Wilmington, Ohio, pending decision about re-erecting the tunnel.[21]

In the midst of the dismemberment and shipping of German equipment, the American aircraft industry also showed intense interest in the Kochel and Oeztal tunnels for its use. General Arnold responded to a query from the Aircraft Industries Association of America, Inc., in his letter of December 4, 1945, Arnold advised that

> Subsequent to the visit of various West Coast aircraft industry representatives to Germany, there has been a great deal of rearrangement of the zones occupied by the Allied Powers. This, in turn, has resulted in several changes in our plans for returning German research equipment to the United States. The United States Army Air Forces in Europe have furnished the War Department with an inventory of the wind tunnels and test installations now under American control and the War Department has already allocated this equipment….Some of the equipment pertaining to the Oetztal 25' wind tunnel has been packed and crated for shipment to this country. Tentative allocation of equipment for this tunnel has been made to the Army Air Forces. It is our plan to assemble and inspect these components after their arrival and, in conjunction with experts from various agencies, to determine whether or not complete reconstruction is feasible. While a definite site for this installation has not yet been selected, it appears quite probable that your suggestion concerning the Rocky Mountain district will be virtually mandatory due to the

[20] Wattendorf, "Historical Aspects"
[21] Wattendorf *ibid*

> tremendous water power requirements. The Air Technical Service Command has been authorized to conduct an informal survey of possible locations for a wind tunnel of this size….The Aircraft Industries Association will be invited to participate in discussions of plans for location and reconstruction the Oeztal tunnel.
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> The various supersonic wind tunnels, now under American control, have been assigned to Government activities and will be reinstalled in the United States as soon as shipment is completed. Specifically, the 40 x 40 cm supersonic tunnel from Kochel has been turned over to the Navy, while others have been turned over to the Army Air Forces and the N.A.C.A.[22]

Headquarters Army Air Forces believed that the Aircraft Industries Association would support the AAF claims for the Oetztal equipment but advised that "the N.A.C.A., however, will undoubtably make a strong bid for assignment of the Oetztal tunnel project to Langley or Ames Laboratory.[23]

By May 1946 the French government had made repeated requests to the War Department for the return to French territory all parts and components of the Oetztal tunnel still in the U.S. zone.[24] The Air Materiel Command obtained from steel contractors an estimate of the value in time and money of using the parts of the Oeztal tunnel in the construction of one of the AEDC tunnels, and the Air Materiel Command planned to bargain with the French for other equipment in the French zone. The Air Materiel Command recommended that von Karman, who was to serve as a representative of the

[22] Letter, H. H. Arnold to Aircraft Industries Association of America, Inc., 4 Dec 1945
[23] Memo, Aiden R. Crawford, Brig. Gen., USA, to Commanding Gen., Air Technical Service Command, subj: "German Wind Tunnels for Installation within the U.S.," 10 Dec. 1945.
[24] Memo, John G. Moore, Col, Air Corps, Deputy Asst. Chief of Air Staff-4, to Commanding General, Air Materiel Command, subj: Oetztal Wind Tunnel Equipment, 16 May 1946.

Army Air Forces Scientific Advisory Board to the Sixth International Congress for Applied Mechanics in Paris, engage in preliminary negotiations with the French.[25]

As planned, von Karman met with French members of the research and development community, who informed him that France wished to re-erect the Oetztal tunnel at Modane in the southeast of France, a site topographically suited for hydraulic drive. The French, however, expressed concern that they had been unable to locate missing parts especially associated with the drive system that had mysteriously disappeared in October 1945. They learned, to their surprise, that Wattendorf had long ago spirited these parts away.

France and the U.S. reached a bilateral agreement that the United States would ship to France the parts of the Oetztal tunnel stored at Wilmington, Ohio, including the drawings, and that the U.S. would further assist French authorities in finding other parts possibly still in the U.S. zone of occupation. In return the U.S. would gain access to information about the operation of the tunnel and would receive favorable consideration for running special tests in the Modane Wind Tunnel.[26] Included in this horse trade was also a provision

> …to admit by the French, American representatives to technical data including drawings for transmittal to Wright Field and to technical installations for inspection in all French zones. Of particular and of immediate interest in this connection are complete drawings of equipment in the French zone pertaining to the Kochel tunnel…as well as all of the design, construction and operational information concerning the Oetztal tunnel.[27]

[25] Memo, D. L. Putt, Col, Air Corps, Deputy Commanding General, Intelligence, T-2 to Commanding General, Army Air Forces, subj: "Oetztal Wind Tunnel Equipment," 29 May 1946.
[26] Wattendorf, "Historical Aspects"; Memo, Aiden R. Crawford, Brig. Gen., U.S.A., to Commanding General, Air Materiel Command, subj: Reconstruction of Oetztal Tunnel," 15 Aug. 1946.
[27] Memo, Paul H. Kemmer, Col., Air Corps, to Commanding General, Army Air Forces, subj: "Reconstruction of Oetztal Tunnel," 25 Jul. 1946.

A draft of the proposed agreement appeared in October 1946.[28]

Kochel

The development of supersonic tunnels in Germany had begun in earnest during the 1930s. With the 1936 establishment of the Peenemunde Rocket Development Station on the Baltic, the Germans began the development of a long-range guided missile, the A4 (V2), with Dr. Werner von Braun as technical director for the project. In 1937 Peenemunde added an Aerodynamics Institute, led by Drs. Rudolph Hermann and Hermann Kurzweg, for the aerodynamic development of the V-2. By 1938 the first of two 40 cm by 40 cm supersonic wind tunnels operated at Mach 2.5. In 1941 the second tunnel in operation achieved Mach 3.3.[29]

Following the air raid on Peenemunde of August 17-18, 1943, the Chief of the Army Weapons Office (*Heereswaffenamt*) decided to move the supersonic wind tunnel to Kochel, Bavaria, where it later operated under the "camouflaged designation" *Wasserbau-Versuchs-Anstalt* (WVA). The move to Kochel required 300 railroad cars for the "two 40 by 40 cm tunnels, the small experimental tunnel intended for the development of higher Mach numbers, the wooden 40 by 40 cm tunnel for subsonic velocities up to Mach 0.4, the compressors, motors, the 41' diameter sphere, and other equipment…. The 18 by 18 continuous tunnel went to Braunschweig.[30] At Kochel the Mach 10 tunnel required 30, 000 KW.

Hitler's increasing desperation in 1944 led to the appointment of SS General Dr. Hans Kammler, a military officer and engineer, who became the supreme commander for

[28] Memo, I. H. Edwards, Maj. Gen., USA, to the Commanding Gen., HQ US Forces European Theater, [subj: Release to the French authorities of the parts of the Oetztal Wind Tunnel still in possession of the U.S. authorities], 4 Oct 1946.
[29] Sam M. Hastings, "The NSWC/WOL Wind Tunnels: A Chronology," Aug. 1979.

all efforts in rocketry.[31] Werner von Braun and Walter Dornberger anticipated that the SS would destroy documents and equipment related to the tunnels rather than let them fall into Allied hands. Reports containing the results of Peenemunde work for the previous eight years had as part of the Peenemunde library been moved to the "Mittelwerk" in Thuringia, which lay under the jurisdiction of General Kammler.

In March 1945 senior scientists drove by night from Kochel to Thuringia with the objective of obtaining the secret archive reports of "series 66," contained in the files of the Peenemunde institution. Von Braun issued orders for them to enter the underground complex, although he was not authorized to do so. The Kochel scientists removed the documents in a bag, concealed them under spare tires and tools in their car, and destroyed the von Braun permit. Then, because General **Keitel** on the same day issued general orders prohibiting the use of any civilian car that used gasoline, the Kochel group drove home at night without lights. Kochel scientists microfilmed the documents and secured them in various places in sealed metal boxes. Meanwhile, the SS loaded the documents still in the complex at the Mittelwerk into trucks and dumped these trucks into the shaft of a salt mine.[32]

One of the participants in the clandestine activity later wrote:

> We were scientists and not fighting people. We could not understand the senseless destruction of scientific equipment with which we had made so many important investigations in the supersonic field during the last years. It was absolutely of no use to anyone in Germany if we should burn all the results of our scientific work. If we did so, we would fall back in our field several years. It was not clear at

[30] "History of the Group of German Scientists (As Recounted by Several German Scientists Who Came to NOL)."
[31] Peter P. Wegener, *The Peenemunde Wind Tunnels: A Memoir* (New Haven, CT: Yale University Press), pp. 93 ff.
[32] Above account taken nearly verbatim from "History of the Group of German Scientists."

> this time which one of the hostile armies would occupy Kochel. However, all efforts were made to save as much as possible of the work already done and to protect the wind tunnel to use it for further work. The development of high-speed flying bodies is one of the most urgent and most interesting technical problems of the near future. The destruction of his tool for this development and the destruction of his own brain work would actually mean the suicide of the scientist.[33]

One week before American troops reached Kochel on May 1, 1945, the scientists defied German orders to destroy all secret equipment and documents. "To protect the hidden documents and equipment from plunderers and souvenir hunters we kept them hidden until the arrival of the first American scientists." The first American commanding officer in Kochel, one Lt. Roberts, signed the first order to protect the WVA.[34]

The U.S. Joint Chiefs of Staff awarded custody of the Kochel tunnels to the U.S. Navy. Custody then passed from the Chief of Naval Operations to the Bureau of Ordnance to the Naval Ordnance Laboratory. An assessment of these tunnels at the time read:

> The White Oak installation will be superior to any existing American supersonic wind tunnel installation and will be capable of investigating fields not accessible to any existing installation. There are at present no tunnels operating in this country at speeds comparable to that reached by the Kochel tunnel (4.4 times the velocity of sound). Such speeds are needed for research on the aerodynamics of very high-speed guided missiles and projectiles….The instrumentation of the German tunnel is believed to be superior in a number of respects to that which is planned for any of the American tunnels.[35]

Wattendorf described the shipment of the Kochel tunnel to the U.S.:

[33] "History of the Group of German Scientists."
[34] *Ibid.*
[35] Cited in Hastings, "NSWC/WOL Wind Tunnels."

> There, Colonel Paul Dane was crating up the main blow-down supersonic wind tunnel and had it all packed in crates. On the site was a Navy observer who was there every day. When the long dismantling and crating process had been completed, Paul Dane said to his Navy friend…"Finally, it's all wrapped up. All I have to do is put on the labels and I'm through." Whereupon the Navy officer said, "Oh, no. I can save you that trouble….I have the labels right here for shipment to the U.S. Navy." Unknown to us, he had obtained authority from the Navy, okayed at a higher level; and so he had the fun of watching Paul Dane of the Air Force complete the elaborate crating process, so that all he had to do was apply the labels.[36]

The train with the tunnel equipment left Kochel in early October, with a Navy Lt. Commander in charge of the shipment. It was this tunnel, requisitioned and set up at White Oak, Maryland, that was the first increment of the new Naval Ordnance Laboratory. Wattendorf considered the tunnel a "spin-off of AEDC…and therefore should have honorary alumnus membership."[37] In an instance of historical irony, the tunnel officially became part of AEDC because of the Base Realignment and Closure of 1995.

"In February 1946 nine key German scientists were transferred from Kochel to NOL to assist in the installation and modernization of the two supersonic tunnels there."[38] Three more scientists followed during 1947 and 1948 under Paperclip.[39]

Bavarian Motor Works

The BMW Engine Test Facility at Munich, the only facility designated for AEDC from Wattendorf's earlier memo that actually became part of AEDC, had first been assigned to the U.S. Navy, but only for testing in Munich. The Army Air Forces

[36] Wattendorf, "AEDC Early Planning," 26 Apr. 1968.
[37] *Ibid.*
[38] Hastings, "NSWC/NOL Wind Tunnels."
[39] *Ibid.*

requisitioned the materiel for re-erection as a first increment for AEDC.[40] NACA's Special Facility on Supersonic Facilities decided in December 1946 that the proposed components test facility {BMW} and the special equipment required for its operation would not be included in the Unitary Plan.[41]

In February 1947 the Joint Chiefs of Staff allocated the complete Bavarian Motor Works plant, together with parts intended for its expansion, to the Army Air Forces, which shipped the materiel to the United States and stored it until the final site selection for AEDC.[42]

SELECTION OF A SITE FOR THE AIR ENGINEERING DEVELOPMENT CENTER

Soon after the War Department approved the Kemmer Committee Report for the "Proposed Air Engineering Development Center," the **Air Technical Service Command** (ATSC) selected five individuals, led by Colonel Kemmer, to search for an appropriate site.[43] The topographic requirement to accommodate the pumped-storage hydraulic drive system for the 100,000 HP Oetztal tunnel significantly limited the options for a site, and the team identified only two U.S. sites that met the requirement: Moses Lake, near Seattle, Washington, and Grand Wash Cliffs, near Kingman, Arizona.

But when the ATSC sent the Kemmer Report to NACA for coordination, NACA presented an alternative plan that included a National Supersonic Research Center, and at its semiannual meeting of 15 April 1946, NACA discussed with the Army Air Forces and

[40] Wattendorf, "AEDC Early Planning," 26 Apr. 1968.
[41] R.G. Robinson, Secretary, NACA Special Committee on Supersonic Facilities, "Revisions in Facilities to be Included in Unitary Plan," 20 Dec. 1946.
[42] Historical Office, Arnold Engineering Development Center, *Chronology of the Arnold Engineering Development Center: Beginning in 1944*, p. 5.
[43] Wattendorf, "AEDC Early Planning."

others the NSRC, AEDC, and recommendations for two supersonic missile development tunnels.[44] As Wattendorf later described the situation:

> Wright Field immediate plans and goals came to an abrupt halt when the coordination process got under way. In April 1946 the National Advisory Committee for Aeronautics formed the so-called Raymond Committee to coordinate facility plans. At this time they disclosed an NACA plan for a new "National Supersonic Research Center" (NSRC). Out of this committee plus a follow-up committee came an agreement that the Air Force and NACA, with the coordination of others concerned, would prepare enabling legislation to present to Congress for a Unitary Wind Tunnel Plan (the larger wind tunnels to be shared between the NACA and the Air Force at the AEDC). Since the final Unitary Wind Tunnel Plan did not include either the Oetztal or Kochel wind tunnels, the Wright Field site surveys were terminated. However, the re-erection of the BMW Engine Test Facility at the proposed AEDC was approved. This facility did not operate by hydraulic drive, so that it was not a factor in site selection. But the concept of having a new Air Force Center without special legislation was a dream of the past.[45]

On June 5th 1946 the Raymond Panel recommended a "Unitary Wind Tunnel Plan" with four major groups: smaller research and training tunnels for universities, larger research facilities for the NACA, development tunnels for industry, and test and evaluation tunnels for the military establishment. The next day NACA formed a special committee on Supersonic Facilities to review the Raymond Panel report, and in mid-June, this committee agreed that the Air Materiel Command should contract with a civilian engineering firm to "conduct a survey, study utility and cost of requirements, and recommend locations for two sets of facilities…an AEDC and NSRC."[46]

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[44] As described in Wattendorf, *Expanded Chronology*, p. 16, Mr. Russel Robinson originated the plan in an internal NACA letter dated 26 Mar. 1946; Minutes, Semiannual Mtg NACA Exec. Comm., 25 Apr 1946 (as cited in Wattendorf, *Chronology*, p. 108).

[45] Wattendorf, "AEDC Early Planning," 26 Apr 1968.

[46] Cited in *Chronology of the AEDC*, p. 3.

The Air Materiel Command awarded the contract for the national facilities studies for both AEDC and the NSRC to the engineering firm Sverdrup and Parcel, Inc., (S&P) of St. Louis, Missouri, at the end of June 1946. S&P studied nine general areas of the U.S.: the Columbia River Region, Pacific Northwest Region, Colorado River Region, Tennessee Cumberland Region, Great Lakes and St. Lawrence Region, Central Texas Region, Central Valley Region of California, Southwestern Region, and the Southeastern Region including Florida. By mid-November the firm had completed its survey, phase I of its contract, recommending Moses Lake, Washington, for AEDC because of the availability of land, water, power, and buildings, and Camp Forrest, Tennessee, for the NSRC. S&P then proceeded with phase II of its contract, the preparation of more detailed designs and more accurate cost estimates for AEDC and its facilities.

By early 1947 the Army Air Forces had settled on the tunnels it wished to include at AEDC: A 40’ by 40’ Transonic Propulsion Tunnel, an 8’ by 8’ Supersonic Propulsion Tunnel, a 15’ by 15’ Supersonic Propulsion Tunnel, a 15’ by 15’ Supersonic Aerodynamic Tunnel, and 10- by 10-inch to 40- by 40-inch Kochel Wind Tunnel. The program also included structures and materials facilities, an electronics facility, a biophysics facility, an instruments facility, a special test facility, propulsion altitude test stands, and static rocket test facilities.[47] Striking about the blueprints for this plan was that each blueprint bore the title “AEDC-NSRC,” and the plan included a drawing of the Moses Lake region.

[47] Army Air Forces Program of Development and Evaluation Facilities for a Proposed Air Engineering Development Center (AEDC): Report for the Joint Research and Development Board, 14 Feb. 1947. According to Wattendorf, the 40’ by 40’ tunnel replaced the 20’ by 20’ tunnel originally allocated to AEDC. Its inclusion in the master plan eliminated the Oeztal 8-meter sonic tunnel. Wattendorf, *Expanded Chronology*, p. 18.

In February 1948 the Research and Development Board Committee on Aeronautics recommended to its executive council that it approve AEDC's 8' by 8', 15' by 15', 20' by 20' wind tunnels and the 10" – 40" Kochel wind tunnel battery. Moses Lake remained the site of choice for AEDC until March 16, 1948, when Secretary of the Air Force W. Stuart Symington and Commanding General Carl Spaatz rejected the Moses Lake area because of its strategic vulnerability.[48] This decision reopened the site selection issue, and Symington appointed a committee, chaired by MIT's Professor John Markham, to restudy sites and recommend an alternative location. This group visited sites at Huntsville, Alabama; Grand Wash Cliffs, Arizona; and Tullahoma, Tennessee, the latter available after NACA dropped its proposal for the NSRC. An unknown individual simply blacked out "NSRC" on the "AEDC-NSRC" blueprints.

In May the Research and Development Board approved Sverdrup and Parcel's alternate site, Camp Forrest (Tennessee Valley), for the Center. Camp Forrest, a 33,000-acre tract in the Tennessee Valley, had housed 22,000 German POWs during the war, and it was genuinely ironic that the U.S. repatriated these Germans at the same time it was importing the Paperclip scientists.

The Research and Development Directorate, however, challenged the choice of Camp Forrest, citing correspondence with the Tennessee Valley Authority to make its case that the immediate availability of the required power in the Tennessee Valley was questionable at best.

In its review of the S&P survey the Research and Development Directorate noted that S&P had eliminated the Colorado River area as a suitable site for AEDC because, in

[48] "Review of the Site Survey for the AEDC," Research and Development Directorate, DCS/M, HQ USAF, Washington, D.C., 30 Dec. 1948.

S&P's opinion, "AEDC would get water from the Colorado River only after the United States Supreme Court told the City of Los Angeles that it would."[49]

The Research and Development Directorate set out what it considered appropriate criteria for site selection: Power, water, living conditions, flying weather, availability of land, availability of labor, proximity to related aeronautical activities (such as Muroc, Wright Field, the aircraft and engine industry, White Sand, Alamogordo, and educational institutions), the suitability of the area for military testing, the use of existing military bases, and railroad connections.

In its findings the Research and Development Directorate noted that the Pacific Northwest would be inappropriate as a site for AEDC not only because of its strategic vulnerability but also because of a critical power shortage. The predicted ultimate water requirements for AEDC, too, were astronomical, given that an estimated future population of the expanded AEDC would be 41,000.

After reassessing the criteria for site selection, the Research and Development Directorate concluded in its review that the Tennessee Valley area did not satisfy the basic requirement of power and that the Colorado River area could meet both basic requirements of power and water. Moreover, the report noted the area's superiority with respect to suitability for military testing and weather as well as living conditions and attractiveness to scientific personnel. The report concluded, "The Air Force would have difficulty justifying before Congress its selection of the Tennessee Valley area as the site for AEDC."[50] One member of Congress, however, Tennessee Senator Kenneth D.

[49] Excerpts from the Minutes of the Meeting of the Scientific Advisory Board, Afternoon of March 17, 1948, on the Air Engineering Development Center, Gen. Sverdrup.
[50] Research and Development Directorate, DCS/M, HQ USAF, Washington, D.C., "Review of the Site Survey for the AEDC," 30 Dec. 1948.

McKellar, who chaired the Senate Committee on Appropriations during the final site selection, thought otherwise.

So on November 9, 1949, days after President Truman signed PL 81-415 but before the Markham committee officially submitted its report, Secretary Symington, with the concurrence of the President, the Secretary of Defense, and the Research and Development Board, announced the selection of the Camp Forrest site for AEDC. The Secretary's announcement marked the end of the three-year, often acrimonious campaign between communities competing for the new Center.

THE GERMAN MODEL OF MANAGEMENT

As planners for AEDC neared determination of site and initial facilities, they had yet to grapple with the problem of management. For advice in this arena they once again approached the Germans. In February 1949 the Air Force asked Walter Dornberger to address the issues of living conditions and availability of labor, two of the ten criteria for site selection set forth in the Research and Development Directorate's analysis. Dornberger opened his remarks somewhat cynically:

> I have been asked what measures ought to be taken to awake and to keep the pleasure of work in a research and development center as the AEDC situated in a boresome place far away from all centers of culture.
>
> Certainly, it will be taken for granted that results in research and development will be obtained quickly and easily with personnel working with pleasure and having achieved a certain degree of satisfaction in personal matters. With such a personnel, in the long run, these results will be obtained cheaper than with personnel permanently dissatisfied, lazy and only loitering during the eight hours of daily work.[51]

[51] Walter Dornberger, "Incentives within the AEDC," Wright Field, 21 February 1949.

Based on his experience at Peenemuende, Dornberger identified and broadly described two models of incentives, the "Eastern method" and the "Western method." He described the Eastern method in disparaging terms, arguing that workers in the East lived primitively, lodged primitively, and acted primitively. In fact, he said, the Eastern population had little culture as compared with that of the West. With that underlying premise in mind, Dornberger laid out the "Western method," the incentives he believed would attract and keep scientists in a remote location.

On Rewards: Dornberger recommended the conferring of decorations and awarding of paid leave for outstanding achievements in technical and organizational fields, the bestowing of titles – even the doctorate – without further examination, based solely on work accomplished at AEDC, and the use of button-hole badges to reinforce solidarity. "Besides these more official rewards," Dornberger continued, "there ought to be a particular fund to give without any delay cigars, cigarettes, and beer to a particular group of personnel for a particular performance." He also recommended more conventional rewards, such as cash bonuses.

On Housing: Dornberger observed that housing families at Peenemunde had been problematic, and he counseled that, during the planning and construction period of a project the magnitude of AEDC, preparing accommodations for families was as vital as the design of the technical facilities. Assuming that the new center would be built away from major metropolitan areas, Dornberger said that all facets of social life must be included in the concept, including apartment houses, churches, swimming pools, shops, drugstores, "and all kinds of accommodations which make life in a community agreeable and worth living for." In fact, he said, town planning must keep pace with the planning of

the technical establishment if the project were to succeed. The Peenemunde management had even transported 100,000 tons of fertile soil more than 30 miles to create parks and gardens for family members.

On Organization and Administration: Dornberger cautioned that "red tape, inexpediency, insufficiency, and especially a vague, tedious and dull administration are generally the reason for dissatisfaction and laziness among the employees….The scientists and engineers should not be suffocated by the paper war and other formalities. They should have their minds free for technical work." The legislative history of PL 81-415 illustrates the extent to which Congress embraced this counsel:

> It is a well recognized fact – recognized even in Nazi Germany – that high-grade scientific personnel will not accept dictation or regimentation of themselves or their ideas if they possess any intellectual honesty or integrity whatsoever. Neither will they tolerate excessive red tape and petty annoyances from minor military or civilian governmental officials who may for a brief space of time wield over them – in the course of rotation of assignments – an overriding abundance of authority out of keeping with their own limitations in technical knowledge and competency in the scientific field involved.[52]

Further underscoring this sentiment was Theodore von Karman's remark in his September 1949 letter transmitting to Air Force Chief of Staff General Hoyt Vandenberg the report "Research and Development in the United States Air Force" – the so-called "Ridenour Report" – after the chairman of a special committee of the Scientific Advisory Board. Von Karman wrote:

> There are also far too few competent civilian technical employees in the Air Force. Those now available are often working under the direct supervision of officers who have insufficient technical qualifications to direct their activities properly. Under no circumstances should a highly technical

[52] "Legislative History," p. 2303.

> job carrying responsibility and authority be filled by anyone except a fully qualified technical man. Actually, in the great majority of technical jobs, it is far more important that the incumbent be technically and administratively competent than that he be an officer.[53]

On Communication within AEDC: Dornberger forewarned that as the proposed center grew individual members of the work force could lose sight of the vision, "not know the goal any more." If that occurred, Dornberger predicted, AEDC personnel would approach their common task with apathy. Peenemuende's leadership had tried to counter this indifference with plenary meetings, reinforcement of the individual's importance to the mission, encouragement of group participation in interesting tests, and organization of exhibitions, "in which the right way was shown in competition with the wrong way."[54]

AEDC's planners also drew extensively on the German model as it concerned the relationship between universities and institutes and the state. In stark contrast with Germany, which had made significant progress in many aspects of aeronautics with close relationships between its government and research institutions of various types, the United States did little prewar contracting for research with colleges, universities, and like institutions. In fact, during the 1930s the total research and development budget of the Army Air Corps was less than $10 million per year, including all funds for basic and applied research and for the development and procurement of new experimental aircraft, engines, and allied equipment. The late Don Eastman, former AEDC Chief Scientist, observed that "the U.S. government was self-centered and self-confident. It considered

[53] Ltr, Theodore von Karman, Chairman, Scientific Advisory Board, to General Hoyt S. Vandenberg, Chief of Staff, U.S. Air Force, [subj:] "Research and Development in the United States Air Force," Report of a Special Committee of the Scientific Advisory Board to the Chief of Staff, USAF, 21 Sep. 1949. Hereafter report cited as "Ridenour Report."
[54] Dornberger, "Incentives."

the nation to be not only impregnable but also the leader of the world in all fields of science."[55]

Three significant education initiatives emerged just as PL 81-115 reached closure. All were at least loosely based on the German model and were intended to remedy a perceived national deficiency. The first was a 1949 a special committee of the Scientific Advisory Board. Known as the Ridenour Report on Air Force research and development (named for the committee chairman Louis N. Ridenour) and prepared for Air Force Chief of Staff, General Hoyt Vandenberg, the Ridenour Report recommended that 2-3 percent of the Air Force research and development budget should be devoted to "making contracts with educational institutions for fundamental research in broad general fields on problems which, without being directed toward definite goals or applications, are of potential interest to the Air Force."[56]

The Ridenour Committee also recommended an acceleration of the process by which AEDC became an operational reality. Wattendorf, a member of the Ridenour Committee and now Deputy Scientific Advisor, Air Engineering Development Center, sought to implement the Ridenour recommendations with an "Arnold Research Institute," a complementary educational institution to attract scientific personnel; this proposal eventually led to the creation of the University of Tennessee Space Institute, which was led by a Paperclip scientist and sited near AEDC, but on a separate piece of land.[57]

The proposed institute's stated purpose was to have a complementary activity of a scientific nature, in which scientific personnel would have the opportunity to do applied

[55] Donald R. Eastman, Jr., "The Story of the University of Tennessee Space Institute (UTSI) at Tuillahoma, Tennessee: The National Context of its Origin and Mission," 5 June 1987.
[56]" Ridenour Report."

research to advance their professional stature; where advanced students could be trained under a university extension program; where students could conduct thesis work for advanced degrees; and where visiting scientists could give guest lectures.[58]

Less than two months after Wattendorf proposed the Arnold Research Institute, the Air Force Chief of Staff established the second initiative, an Industry and Educational Advisory Board (IEAB) consisting of five members of the Aircraft Industries Association and two university representatives. In 1950-51 this body discussed a program of AEDC-university affiliation that would attract capable technical and scientific personnel to the center. Ties with neighboring universities would not only give engineers the opportunity to further their technical education but also give key technical personnel research and teaching opportunities.

Yet a third dimension of this focus on academic ties appeared in June 1951, when the Air Force awarded a letter contract to the University of Tennessee for a study along the lines of the IEAB's recommendations. The University Affiliation Study established five *ad hoc* committees to facilitate the exchange of ideas between AEDC and the academic world.[59]

While Congress eagerly embraced some German models, including morale and education programs, other issues were more troublesome. In particular, the matter of concentrating facilities in a single location or dispersing them throughout the U.S. provoked a thoughtful discussion:

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[57] Memorandum for the Record, Frank L. Wattendorf, Deputy Scientific Advisor, Air Engineering Development Division, subj: "Arnold Research Institute," 1 June 1950.
[58] Wattendorf, "Arnold Research Institute."
[59] The University of Tennessee, "AEDC-Universities Affiliation at the Arnold Engineering Development Center," 1 Dec. 1952.

> One of the reasons given by the Air Force in justification of this center is that Wright Field is already badly overcrowded and can no longer accommodate additional facilities. Great stress is laid upon the fact, moreover, that the present installation at Wright Field presents a concentration of facilities which is strategically undesirable from the standpoint of possible enemy air attack.
>
> There appears to be a definite inconsistency between this view and Air Force plans for a huge new supersonic center patterned more or less along the lines of the vast German establishment at Peenemunde. This inconsistency becomes even more apparent when it is considered that the vulnerability to allied bombardment of the installation at Peenemunde compelled the Germans to disperse many of its activities, thus entailing the removal of wind tunnels and other facilities to Kochel and other locations scattered throughout Germany.[60]

A second major departure from the German model concerned what Congress called "overemphasis upon security considerations."[61]

> While the Germans recognized the necessity for independent research, perhaps their greatest fault tending to nullify the benefits to be derived from these sound principles of scientific organization lay in their overemphasis of security measures. In consequence, scientists working on a particular project in one laboratory frequently did not have the slightest inkling as to how their work fitted into the over-all pattern of German military effort. It was the exception rather than the rule for the scientist to know the identity of the particular weapon or type of weapons toward the perfection of which the results of his work were to be applied. It was for American technical teams who combed the German laboratories for evidence and cross-examined German scientific personnel after VE-day to piece together the fragments of the jigsaw puzzle and thus determine the outlines of the broad programs being followed by the Germans.
>
> It is significant that the advantages to be gained through such a policy in terms of military security may very well be more than offset by far greater disadvantages resulting from

[60] "Legislative History," pp. 2310-11.
[61] "Legislative History," p. 2304.

> unreasonable obstacles to the free flow and exchange of ideas among one's own research workers and technical personnel.[62]

In fact, Karl T. Compton, Chairman of the Research and Development Board, underscored this concern in his address at the dedication of the Naval Ordnance Laboratory Aeroballistic Research Facilities:

> To a rather astonishing degree, in the public and even in the military mind, security has come to mean secrecy. Secrecy is one aspect of security, for it is evident that, if we should freely broadcast all information about our new developments, we would permit our competitor to keep pace with us at relatively little expense to himself. Thus secrecy is the negative, or defensive, aspect of security. But if we simply sit tight and lock up our secrets, it will not be long before our active competitor forges ahead of us. So we must also press forward the positive, or offensive, aspect of security by making rapid advances in our own science and its practical applications.
>
> Unfortunately, secrecy and progress are mutually incompatible. This is always true of science, whether for military purposes or otherwise. Science flourishes and scientists make progress in an atmosphere of free inquiry and free interchange of ideas, with the continual mutual stimulation of active minds working in the same or related fields. Any imposition of secrecy in science is like application of a brake to progress.
>
> It is for this reason that the most advantageous path between secrecy and progress is difficult to define….I am sure that the pendulum has recently swung so far in the direction of concern over secrecy regarding even little details and unimportant people that our real security is suffering. It is suffering from the slowing up of progress because attention is being diverted from the really big things which need to be done.

But despite all the hurdles: the issues of appropriate facilities, site selection, administrative models, competition between agencies and among countries, and

[62] "Legislative History," p. 2304.

underlying philosophy of research and development, AEDC welcomed the President of the United States at the center's dedication on June 25th, 1951.

PRESIDENTIAL DEDICATION OF AEDC

The flawlessly executed dedication of Arnold Engineering Development Center (AEDC) was remarkable in every respect. Headquarters, Air Engineering Development Division first learned about Presidential participation in the ceremony on June 4, 1951. During the ensuing 21 days planners had to address every detail of the President's 5-hour visit: Invitations, completion of the warehouse where the event would occur, security, preparations for a dinner for 450 guests, design of the ceremony itself, housing in the surrounding communities, and a host of other tasks.

Those in military circles noted the rarity of the event, a military technology center established by Public Law and dedicated by a President. The date chosen for the ceremony – June 25th – lent even greater significance. This was the 65th birthdate of the late General Arnold and the first anniversary of the outbreak of the Korean War. During World War II, Harry S. Truman had become friends with General Arnold; as President, Truman took a personal interest in such a critically important installation as AEDC. "[General Arnold] knew that you can't have a first-class air force with a second-class aircraft," said the President. "He would have been much delighted with this air-research center, which will do so much to make further improvements possible….The scientists who work here will explore what lies on the other side of the speed of sound. This is part of our effort to make our air power the best in the world – and to keep it the best in the world."[63]

[63]Presidential Address, Arnold Engineering Development Center, 25 June 1951.

In addition to his tribute to General Arnold and to AEDC, President Truman had yet a third reason for his visit to Middle Tennessee. Just one year earlier, on June 25th, 1950, Communist North Korea had crossed the 38th parallel. In his remarks on the subject, the President said, "On June 25, 1950, one year ago today, the communist rulers resorted to an outright war. They sent communist armies on a mission of conquest against a small and peaceful country. That act struck at the very life of the United Nations. It struck at all our hopes for peace."[64] Threads of the emerging Cold War tapestry were woven throughout the entire fabric of AEDC's advocacy and funding. The initial ATSC site survey in 1946, for example, began just one month after Winston Churchill's "Iron Curtain" speech at Westminster College, and Korea dwarfed the battles for funding PL 81-415.

Imagine the clash of cultures that occurred on that day of dedication. In attendance were the President of the United States, the Secretary of the Air Force, the Chief of Staff of the Air Force, nearly every Congressional delegate from the state of Tennessee, the Governor, dignitaries of every town within miles, and General Arnold's widow and three sons. The Chief of Staff of the Air Force was allotted one minute for "brief comments."[65]

Organizers of the dedication ceremony timed an aerial salute to the President, to the memory of General Arnold, and to AEDC, to coincide with the end of the President's speech. The flyover included 16 F-84 Thunderjets, 16 F-86 Sabrejets, a B-17 Flying Fortress – the workhorse aircraft of the European theater – several B-29 Superforts – an aircraft used in the war against Japan – and a 600-mile-per-hour Boeing B-47 Stratojet

[64] Presidential Address.
[65] **Official AEDC History.**

Bomber, which made the 630-mile flight from Wichita, Kansas, in approximately one hour.

The President then unveiled the official plaque, a bronze tablet embedded in a nearly three-ton stone (nicknamed "Lulu") brought from a forest ravine on the University of the South domain, and the official party adjourned to the warehouse dining room, where the President ate fried chicken and apple pie catered by the Maxwell House Hotel, tried on a hat presented him by the Tullahoma, Tennessee, Jaycees, and listened to a Nashville quartet sing "Tullahoma Greets You, Mr. President," which a Tullahoma woman had composed for the occasion.

According to the official Center history, "At 2:45, the President, still smiling and waving and still being photographed, disappeared into the 'Independence,' [now on display at the United States Air Force Museum in Dayton, Ohio] and Arnold Engineering Development Center personnel changed their verbs from future to past tense and busied themselves returning borrowed materials and writing thank-you notes."[66]

President Truman's visit was not, of course, the end of the story but the beginning. During Truman's visit the just completed building was the warehouse. Soon to follow would be the facilities of the AEDC "interim program," including the Engine Test Facility, the Gas Dynamics Facility (later dedicated in honor of von Karman), and the Propulsion Wind Tunnel, AEDC's Unitary Plan tunnels.

The brochure distributed during AEDC's dedication ceremony on June 25th, 1951, featured a dam on its cover and the caption "Under Construction by Tullahoma District, Corps of Engineers, U.S. Army." Land area for the new center was approximately 41,000 acres, of which 7,278 acres were required for the Elk River Dam and Reservoir and

approximately 34,000 acres – all within the old Camp Forrest reservation and ceded to the federal government for the bargain-basement price of $1 – for the center itself. Engineers faced the daunting task of building AEDC's initial facilities and infrastructure on essentially rural land -- with the exception of the few remaining foundations from Camp Forrest that had proved too difficult to remove easily. Relocation of the roads in the construction area was relatively minor. Only a few county roads and bridges required relocation to provide access for the local people living in the area of the reservoir. Including the 1950 amendment to PL 81-415, Congress designated $157,500,000 for construction of the initial facilities.[67]

In February 1950 the Panel on Facilities, Research and Development Board, Committee on Aeronautics, recommended as its first priority construction of the High-Altitude Engine Test Facility; consequently, the Engine Test Facility (ETF) was the first test unit built at the center. The ETF, constructed from the BMW materiel, was the only facility from Wattendorf's 1945 memorandum that actually came to AEDC. In May 1950 personnel of the Office of the Deputy for Materiel, Air Engineering Development Division, completed their inspection of captured German and Japanese equipment for the ETF stored at Alameda, California; Mobile, Alabama; and Memphis, Tennessee, and in August, William Northern Field, Tullahoma, Tennessee, received the German equipment: 52 carloads and 2 barge loads from Alameda, 6 carloads from Memphis, and 450 tons from Mobile (58 railroad cars, 2 barges, and multiple heavy trucks.

[66] History
[67] Amended 21 Sep 1950 by PL 81-799, providing additional appropriation of $57,500,000 for establishment and initial construction, installation, and equipment of Air Engineering Development Center.

Designed for testing turbo-jet and ram-jet power plants under simulated flight conditions and altitudes up to 80,000 feet, ETF could produce temperatures as low as minus 120 degrees Fahrenheit. It required 75,000 horsepower to operate, with the plant constructed around the modernized and expanded German plant. Planners envisioned that the ETF testing capacity would be six to eight times that of the Wright-Patterson facilities. The ETF's basic components included its refrigeration drying equipment, four air supply compressors, three test chambers, a test bed, exhaust gas coolers, and six exhausters. Railroad tracks provided the means to transport engines to the test bed.

The second priority facility for AEDC was the Gas Dynamics Facility (GDF), later dedicated to Theodore von Karman as the von Karman Facility (VKF). GDF was designed to enable testing of developmental models of aircraft and guided missiles and their components through the supersonic and into the hypersonic ranges. The GDF's test sections each had adjustable nozzles, tunnel ducting, optical instruments, force- and pressure-measuring instrumentation, and heat exchangers and driers. 90,000 horsepower electrical motors drove the compressor system. The complexity of GDF illustrates the challenges that faced the early engineers: although the major facility consisted of two test sections, the flexibility of the centrifugal compressor system made it possible to operate other test sections from the same compressor plant. Synchronous motors drove twelve centrifugal compressors at extremely high speed, producing high temperatures.

The third principal test unit to be constructed at AEDC was the Propulsion Wind Tunnel (PWT). The transonic leg was installed first, then the supersonic leg as Congress appropriated additional funds. Designed for developmental testing of full-scale, operating ram-jet and turbo-jet power plants as they might be installed in missiles and aircraft as

well as full-scale components of aircraft and missiles, PWT created wind speeds that extended from the high subsonic into the supersonic. At the time of its construction PWT housed the largest piece of rotating equipment of its kind ever constructed. The multistage compressor system required more than 200,000 horsepower to operate, a power demand equivalent to the entire greater Nashville area at that time. The wind tunnel required 100,000 gallons of cooling water per minute, water pumped from the reservoir formed by the Elk River Water Supply Dam and equal to that of a city about the size of Washington, DC. In November 1989 the American Society of Mechanical Engineers (ASME) designated PWT as an International Historic Mechanical Engineering Landmark, only the 28th such designation.

AEDC's first Commander, Major General Franklin O. Carroll, envisioned a transition period during which AEDC would gradually develop as a major Air Force research and development center with responsibilities much broader than the operation of the initial program of facilities. The transition, he believed, would include the planned dispersal and eventual withdrawal of research and development facilities and associated personnel from the Wright Field laboratories and their transfer, at least in part, to AEDC.

The 1951 master plan for AEDC still contained a section on proposed facilities, including a nuclear propulsion test unit for the ETF, a propulsion components laboratory for the ETF, an instrumentation and data processing laboratory, a special projects facility, a propeller dynamometer for the PWT, and a structures test facility.[68] But, despite the plan for the larger AEDC, security issues such as dispersal of facilities, interagency squabbles, and funding concerns eventually subdued proponents.

[68] Analysis of General Master Plan for Arnold Engineering Development Center, Tullahoma, Tennessee, 27 Dec. 1951.

EPILOGUE

So AEDC turned out to be not a "dull and boresome place" after all, but a thriving center that became the critical link between identified requirements and flight. From its earliest days AEDC grappled with issues such as the appropriate and effective relationship between the state and the scientist, the role that universities and research institutes could and should play, the fundamental essentials of culture necessary to nurture the scientists and their families. To their great credit, those responsible for planning and building the center laid a foundation for fifty years of service to this nation, service for which the AIAA named AEDC a 2001 Historic Site, an honor of which we are most proud.

APPENDIX A

LINEAGE AND HONORS DATA
OF
ARNOLD ENGINEERING DEVELOPMENT CENTER (AFMC)

UNIT DESIGNATION:	Arnold Engineering Development Center
PREVIOUS DESIGNATION:	Air Engineering Development Division
AUTHORITY:	HQ ARDC GO 32, 31 July 51
HIGHER HEADQUARTERS:	Air Force Materiel Command (AFMC) (DAF SO GA 443, 1 Jun 92)
COMMANDER:	Colonel Michael T. Brewer Aug 2011 – Present (AFMC SO GA-11-02)
VICE COMMANDER:	Colonel Eugene W. Mittuch Jul 2009 – Present
ASSIGNED UNITS: (Inactivated 30 Jun 2010)	704th Maintenance Group 704th Maintenance Squadron 804th Maintenance Squadron 704th Test Group 716th Test Squadron 717th Test Squadron 718th Test Squadron 704th Mission Support Group 704th Communications Squadron 704th Civil Engineer Squadron 704th Test Systems Group 650th Test Systems Squadron 651st Test Systems Squadron Inactivated 656 Air Base Squadron (AFMC SO GA-18, 3 Sep 96) Redesignated 656 Air Base Squadron (AFMC SO GA-20, 1 Mar 94) Redesignated 656 Support Squadron (AFMC SO G-191, 1 Oct 92) 4960th Air Base Squadron, 1 Mar 72

UNIT AWARDS: 656th ABS, AFOUA (AFMC SO GB-62, 25 Nov 96)

STATION: Arnold Air Force Base, Tennessee
(DAF SO GA-3, 28 Sep 95)
Arnold Air Station, Tennessee
(DAF SO GA-1844, 17 Aug 94)

PREVIOUS DESIGNATIONS: Arnold Engineering Development Center[69]

OL-AC Inactivated* (AFSC SO GA-70, 27 Sep 91)

OL-AA & AL-AB Inactivated* (AFSC SO GA-45, 6 May 91)
(AFSC SO G-4, 7 Oct 87)
(DAF SO GS-36, 22 May 79
(DAF GO 35, 15 Jun 56)
(DAF GO 27, 30 Mar 55)
(DAF GO 23, 7 Mar 50)

Air Engineering Development Center
(PL 415, 81st Congress, 27 Oct 49)

*Operating Locations assigned to AEDC: Hypervelocity Tunnel 9
White Oak, MD
National Full-Scale Aerodynamics Complex (NFAC)
Moffett Field, CA

AIRCRAFT FLOWN: None

AWARDS AND DECORATIONS:

[69] DAF General Orders for the period 1952-1960 provided no authority designating the installation for the Arnold Engineering Development Canter at Tullahoma as Arnold Air Force Station. Similarly, no orders of ARDC and AFSC or of the Center authorized or announced the designation of Arnold AFS. All General Orders of the Center through 26 Aug 59 bore the letterhead: "Headquarters, Arnold Engineering Development Center (ARDC), United States Air Force, Tullahoma, Tennessee." Between 24 Sep and 9 Oct 59, "Arnold Air Force Station, Tennessee," replaced Tullahoma. Ltr (U), A. Timothy Warnock, Dep Chief, Research Div, HQ USAFHRC, to David M. Hiebert, AEDC Historian, "Arnold AFS," 15 Jan 91; Ltr (U) Maurer Maurer, Chief, Historical Research Branch, Historical Research Div, to HQ AFSC/SCEH, "Documentary Authority for Designation of Arnold Air Force Station, Tennessee," 21 Aug 69. I have meticulously reconstructed the Lineage and Honors data with files obtained from the USAF Historical Research Center and from HQ USAF's Real Property Division. These documents include all DAF orders as well as the three Installations Characteristics Reports for the Center. The heritage of the Center and that of the Base appear to be tangled.

AFOEA-DAFMC-GB-006	(1 Jun 06 – 31 May 08)
AFOEA-DAFMC-GB-91	(1 Jun 95 - 31 May98)
AFOEA-DAFMC-GB-20	(1 Jun 93 - 31 May95)
AFOEA-DAFSC-GB-110/91	(1 Jun 89 - 31 May91)
AFOUA-DAFSC GB-484/85	(1 Jan 83 - 31 Dec 84)
AFOEA-DAFSC GB-345/79	(1 Jan 76 - 31 Dec 77)
AFOEA-DAFSC GB-873-75	(1 Jan 73 - 31 Dec 74)

Mission[70]

AEDC is a national aerospace ground test facility that conducts tests, engineering analyses, and technical evaluations for research, system development, and operational programs of the Air Force and Department of Defense, other government agencies, and industry. Using ground test facilities, AEDC supports propulsion, aerodynamic, reentry, transatmospheric, and space flight systems testing. Testing is performed in an environment that simulates operational conditions. AEDC performs research to develop new technology for advanced test facilities, test techniques, and measurement methodologies associated with ground testing.

[70] AFMC Mission Directive 405, dated 18 April 2002. Certified current 14 November 2011.