Of Aeronautics, Aerophysics, and Aerospace: A History of Aerospace Engineering at Mississippi State University

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To Aero or Not to Aero?

Aeronautical engineering at Mississippi State began in a somewhat indeterminate manner. In 1932, the board of trustees for the college, in response to the urgings of various groups, issued a directive that Mississippi State College (MSC) begin offering courses in aeronautics. However, the wording of the directive was vague enough that Hugh Critz, president of MSC, decided to appoint a committee to interpret the directive to determine if that was in fact what the board had intended. The conclusion of the committee was "yes," and so the first students were admitted into the new aeronautical engineering program in September of 1933. Unfortunately the board did not provide any funding for the new program, which began as something of a foster child in the Mechanical Engineering department, as a subdivision of ME (Haug, p. 62; see "Note on Sources" at end of article).

The beginnings of aeronautical engineering at MSC were not much less definitive than the beginnings of engineering in general at the college. In 1878, a new College of Agricultural and Mechanical Arts had been established in Starkville, Mississippi, the new Mississippi A&M. The first president of the new college was former Confederate lieutenant general Stephen Dill Lee. When the new A&M college was created, however, funding was only provided for traditional liberal arts and agricultural education, and none for the "mechanical arts" (Haug, p. 9). In fact, according to Haug (p. 10), Lee actually resisted the addition of what he called "the mechanical feature." In 1888, Buz Walker joined the faculty as a professor of mathematics. Walker began to add education in the "mechanical arts," in the areas of surveying, statics, dynamics, elementary mechanisms, and fluid mechanics, in addition to such civil engineering topics as trusses, mechanics of materials, and railroad roadbed construction (Haug, p. 12). By 1892, instruction in the "mechanical arts" had become a permanent feature of the new college. The formal establishment of a School of Engineering at Mississippi A&M followed in 1902 by action of the board of trustees of the college. Walker was named the director of the school and shortly afterwards became the first Dean of Engineering at Mississippi A&M (Haug, p. 24). Mississippi A&M became Mississippi State College in 1932.

The urgings which prompted the board of trustees to create the new program in aeronautics may have come from diverse sources, but one of the leading proponents of the new program was Mitchell Robinson, who in 1932 became the new College Secretary, a position equivalent to today's Vice-President for Business Affairs (Barnett, p. 19). The late 1920s and early 1930s was one of the golden ages of aviation, and Robinson could see the potential for growth in this new field, in both technical and commercial applications. To him, aircraft manufacturers, airlines and airports represented a new source of economic growth for the state, and he was determined that MSC would play a role. In fact, the new program that emerged was "Aeronautical Engineering and Commercial Aviation," and was open to both engineers and business majors (McKee, p. 36).

At that time, all engineering students at MSC had common programs for the first two years of study. Courses included algebra, trigonometry and calculus, as well as mechanisms, surveying, forge shop, and foundry. For the first year of the new aeronautical engineering program, juniors took Practical Aviation, which according to the catalog covered the material necessary in a Transport Pilot's ground school. They also took Simplified Aerodynamics, which included performance, stability and control and which reflected a common tendency of the time to lump all of aeronautics under the heading "Aerodynamics." Separate disciplines of aerodynamics as purely a study of fluid flow, aircraft performance, and stability and control would emerge later. Since as stated in the 1934-1935 MSC catalog the purpose of the program was "to train engineers rather than aerodynamicists; engineers who can take part in the practical work of designing,

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building and developing aircraft and aircraft engines on a scientific basis," juniors also took Airplane Welding and a second semester of Practical Aviation, which this time concerned itself with "advanced work in doping, gluing, and rigging." The next year, the first seniors would take Airfoils and Airscrew Theory, Airplane Design, Airplane Engine Laboratory, and Airplane Structures, in addition to other engineering and mathematics courses. Over on the business side, the Commercial Aviation students were taking Practical Aviation, Airport Management, Commercial Aviation, Aviation Law and Commerce Rules, Transport Aviation, and Airports and Civil Airways.

All of these courses were taught by two individuals. The first aeronautical engineering faculty member was Kenneth Withington, who had received his B.S. degree from Alabama Polytechnic Institute (now Auburn University) in 1931 and who would later receive an A.E. degree from API in 1936 (Barnett, p. 23). The second was Mason Sumter Camp, who had graduated from the Robertson School of Aviation in St. Louis in 1926. Camp's graduation certificate and his license were both signed by his instructor, one Charles A. Lindbergh. Camp had returned to Starkville prior to 1933 with the primary goal of establishing a flying school and airport in the area. Camp was hired as a flying instructor, but his duties included classroom work as well. He had the responsibility of teaching the junior level courses and Withington taught the senior level courses (Barnett, p. 23). Camp's formal status as a faculty member in aeronautical engineering would remain somewhat nebulous, as later history will demonstrate.

After one year of being located in the ME department, Aeronautical Engineering (hereinafter "AE") became a separate department starting with the 1934-1935 school year. Withington, who had been an assistant professor of mechanical engineering, was named department head. The aeronautics courses which had been taught as ME courses now had their own prefix, "Av" (at the time, "AE" was already taken by the Agricultural Engineering department). The new department still had no direct funding for faculty, offices, laboratories, or equipment. On loan from the U.S. Army Aviation Corps was a Curtiss P-1F pursuit plane, a Douglas O-2H observation plane, and a Liberty V-1650 aircraft engine, none of which was flight-worthy (Haug, p. 63; McKee, p. 36). Since there was no building to store these in, they were placed in a Dairy Judging Pavilion where they were used for instructional purposes. However, the pavilion remained in use, so the planes were damaged by visitors to the pavilion and by the rats that made homes in the aircraft and chewed the fabric and wood. Indeed, the conditions were so bad in general that Haug summarizes the state of the department in 1938 as follows: "From the beginning, courses were taught in a dairy barn by inexperienced faculty members without advanced degrees using borrowed, obsolete equipment" (Haug, p. 66).

Peacetime and Wartime Training

Despite its austere beginnings, the new aeronautics program managed to keep itself aloft. The first class received B.S. degrees in May of 1935. In the second group of graduates, those who received their degrees in 1936, was one Franklin Sproles Edwards, a future head of the AE department at MSC. Even with the lack of funding, the program was successful in attracting students. Department head Withington attributed this to his success at placing his graduates in jobs, with AE having the highest placement rate in the School of Engineering (Haug, p. 63).

The Airplane Design course that Edwards took in his senior year in 1936 had a slightly different description than the previous year. According to the new description, each student "design[ed] an airplane," which perhaps underscores the simplicity of airplane design in 1936 relative to today's complex aircraft. Topics listed for the course were "a detailed study of plan form, flaps, etc.; parasite drag; stability and control; and performance calculations for each design." The second semester of design was conducted "with reference to the Bureau of Air Commerce design regulations" and "design loads caused by the various maneuvers [were] calculated for each part."

Word was received in 1935 of possible federal funding for aviation training, a goal of Franklin Roosevelt's since he had been elected President in 1932 (Barnett, p. 38). In order to improve their chances of obtaining funding under this effort, the AE department conducted an extensive study of the state of aeronautics in the country, including a survey of aircraft manufacturers that included Pratt and Whitney, the Wright Aeronautical Corporation, and the Glenn-Martin Company. The survey presented information on the current status of aeronautics instruction at MSC and requested feedback on areas of possible improvements. The results of the study were used to make revisions in the program curriculum, an early example of external assessment of the program (Barnett, pp. 38-39).

In 1937 the AE department had the distinction of enrolling the first female student in the School of Engineering at MSC. Ms. Cora D. McDonald graduated from the program in 1940, becoming the first woman to receive an engineering degree from MSC. Part of the AE curriculum at the time was flight training, and some time after her graduation in 1940, during WWII, McDonald served as a ferry pilot (McKee, p. 45).

In 1938 it was announced that certain locations in the U. S. would be selected as experimental federal aviation schools, and MSC set out to land one of these schools. Even the president of the University, George D. Humphrey, exerted considerable effort to try to obtain one of the schools for MSC, contacting officials of the Civil Aeronautics Authority and members of Mississippi's congressional delegation. In January of 1939, the list of selected locations was announced, and MSC was not on the list. Humphrey continued his efforts, and the dean of the School of Engineering, L. L. Patterson, traveled to the University of Alabama with AE department head Withington to determine what could be done to improve the curriculum. The result of that study was the hiring of an additional faculty member, Thomas H. Dalehite, who received his B. S. in AE from MSC in 1939 (Barnett, pp. 47-51).

The federal aviation training program was expanded in 1939, and MSC's efforts finally paid off. In September of 1939 Humphrey was informed that MSC had been selected to participate in the program, and that the school to be established in Starkville would train up to forty students, making it one of the largest such training facilities in the region. The instruction consisted of seventy-two hours of classroom study and thirty-five hours of flight training. Withington, Camp and Dalehite were all examined and licensed as ground school and flight instructors (Barnett, pp. 52-55).

In 1940, AE finally obtained its first laboratory facility, although not the one that had been on the university books for construction since 1935. The basement of the Student Activities building was cleared out and converted into an engine laboratory. The facility did at least have two new engines, which had been donated by the Army, as well as some other used equipment (Barnett, p. 57).

The next significant event for AE occurred in 1941, when Franklin S. Edwards returned to MSC to join the AE faculty. Edwards had been working in industry since his graduation in 1936. Edwards remained at MSC until 1944, when he took leave to attend the California Institute of Technology. He received his M.S. in Aeronautics from Caltech in 1945 and returned to the AE faculty at MSC.

The war took its toll on the AE faculty. In 1942 Dalehite left on a military leave of absence and did not return to the department. In 1942 Withington requested that Camp be hired to assist in AE instruction, but his request was denied. Then in mid-February of 1942, Withington himself was called up to active duty in the U. S. Army Corps of Engineers. Camp was named acting department head and Edwards was put in charge of the pilot training program. Four student assistants were hired as temporary instructors, their pay coming from the remains of Withington's salary (Barnett, p. 64). However, by 1945 Camp was so involved with pilot training for the Army that his services to the college essentially ended, leaving Edwards as the sole AE faculty member after his return from Caltech (Haug, p. 78). The classroom load would not have been heavy, however. By the 1944-45 school year, enrollment at MSC had dropped from a peak of 2,327in 1939-40 to a low of 404. Only twenty-one students received degrees from the college, and only six in engineering (Haug, p. 78).

The department and the university faced another significant challenge during the war. In 1943, the governor of Mississippi, Paul B. Johnson, Sr., proposed a committee to investigate the creation of a School of Aviation at MSC. This move met with violent opposition from MSC president Humphrey, who felt that the creation of such a school would endanger not only the chances of accreditation of the School of Engineering but also the chances of the college as a whole. According to Barnett, Humphrey "risked his position as President, verbally attacking the Governor of Mississippi, in order to preserve the past and future reputations of both the Department of Aeronautical Engineering and Mississippi State College" (Barnett, pp. 68-70). The proposal was eventually withdrawn.

Even with the war over, funding for the department did not improve. In 1946, Withington wrote to Dean Patterson, listing immediate needs as an exclusive departmental office and sufficient storage space. According to

Withington, the department "has always been seriously handicapped." Unfortunately, Patterson's response struck Withington as inadequate, and Withington submitted his resignation, effective July 1, 1946 (Barnett, p. 75). Edwards was named the department head.

The Research Feature

For many years there had been little motivation for MSC or its School of Engineering to become involved in research. Instruction had been its primary task, and some leaders had actually viewed publication as attempts by faculty to generate publicity for themselves. However, in the 1940s the School of Engineering began to re-evaluate this position. In 1941 the board of trustees authorized the creation of the Engineering Experiment Station, whose purpose was to determine "new or more economical uses for the natural resources of the state as they apply to engineering and industry." The demands of the war prevented the college from beginning a new program at that time, however, and the Station lay dormant until 1944 (Haug, p. 75).

In 1944, Dewey McCain, a professor of civil engineering, became assistant director of the Engineering Experiment Station, based in large part because of the research contract he had received from the Tennessee Valley Authority to study "Wood Joints made with Nails in Drilled Holes." This was the first externally-funded research conducted in the School of Engineering. His experience on this project opened his eyes to the value of research to the School of Engineering, and so he began advocating a greater role for research (Haug, pp. 82-83).

The efforts by various people to expand the research function in the School of Engineering began to pay off in 1948, when Dean Patterson hired Harold von Neufville Flinsch as a professor of civil engineering and associate director of the newly-renamed Engineering and Industrial Research Station (EIRS), with the understanding that Flinsch would become dean and director of EIRS upon Patterson's retirement. Flinsch had received the first Ph. D. in engineering at the University of Minnesota in 1941 for his work on the energy contained in ocean waves. Patterson retired as planned in 1949, and Flinsch became Dean of Engineering (Haug, p. 91).

Flinsch was given two primary duties as dean: increase the number of faculty with terminal degrees and expand the research programs in the School of Engineering. Budgetary and other constraints prevented rapid progress on the first goal. However, Flinsch could do something almost immediately about the second. Flinsch was a pilot and a sailplane enthusiast. He was familiar with sailplane research in Germany prior to WWII that had led to advances in aircraft technology, and had made particular note of the fact that such research could be done relatively inexpensively. He decided that if certain universities in Germany with limited means could conduct such research, there was no reason why Mississippi State College could not have a similar program. The effort to begin such a program brought him into contact with Dr. August Raspet, and the course of the history of the School of Engineering was changed (Haug, p. 94).

Raspet had graduated from the Carnegie Institute of Technology and gone on to receive a Ph. D. in physics from the University of Maryland in 1942. Like Flinsch, Raspet was a sailplane enthusiast and had achieved some recognition in this area. He served as director of the research phase of the Thunderstorm Project in 1946. In this project, he and other pilots would fly sailplanes into thunderstorms and the motions of the sailplanes would be tracked on radar, yielding information about the wind currents within the storms. Upon completing this project, he moved to New York, where he became the director of the Aerophysics Institute and began work on a grant from the Office of Naval Research (ONR). The purpose of this study was to use sailplanes to study airflow patterns over mountain ridges (Haug, pp. 94-95).

Flinsch contacted Raspet about moving to Mississippi State and beginning his own independent sailplane research program, which he did in February of 1949. From the beginning, Raspet was a very productive research scientist, but since he was essentially the only one in the School of Engineering, Flinsch had to figure out what to do with him. Since his degrees were in physics, he couldn't teach engineering courses. Also, since a heavy teaching load for each faculty member was one of the main impediments to research, Flinsch didn't necessarily want to put him in a classroom. Therefore he created the Department of Aerophysics just for Raspet and his sailplane research (Haug, p. 95).

The first project undertaken by Raspet upon his arrival at MSC seems to suggest a desire by Raspet to assimilate himself to his new surroundings. Raspet chose to study the aeronautics of bird flight by using his sailplanes to trail the local buzzards as they soared over the outskirts of Starkville. Raspet believed that an understanding of low-speed flight as illustrated by these birds would lead to improvements in low-speed aircraft performance, particularly as applied to short take-off and landing (STOL) aircraft currently under development. His preliminary results were sufficient that he was awarded a grant of $16,000 by the ONR to study the performance of soaring birds, the first large federal research grant ever received by the School of Engineering (Haug, p. 96). The research effort in engineering had literally taken off.

A Stearman biplane was purchased as a towplane (note: this aircraft is still owned and operated by the department). Several sailplanes were either purchased or donated, leading Flinsch to state that the Aerophysics Department was now ready to begin meteorological and aerodynamic studies that could not be performed anywhere else (Haug, p. 96). Interestingly, in order to perform their new duties, Raspet and his assistant, Mel Swartzberg, still had to be licensed as pilots, despite their considerable experience in sailplanes. This brought them into contact with Sumter Camp, the flight instructor, who recognized their abilities as pilots and was able to convince the FAA to reduce their required number of training hours (Barnett, p. 96).

Raspet's national reputation, and his presence at MSC, attracted other sailplane enthusiasts to Starkville. One of these was Dick Johnson, a native of California. Johnson came to MSC in 1950 and constructed his own sailplane, the RJ-5, under the direction of sailplane designer Harlan Ross and with the assistance of Raspet. Johnson used this sailplane to first win the 1950 national soaring championship, and then to set a new soaring distance record of 545 miles from Odessa, Texas to Salina, Kansas in August of that year. Johnson would go on to set numerous other sailplane records (Barnett, p. 100, p. 107).

Meanwhile, Back in the Classroom…

The Department of Aeronautical Engineering continued its slow but steady development. In the 1947-48 school year, one of the undergraduate courses, Applied Aerodynamics, mentioned "compressibility effects," the first such mention of the phenomena of compressible flow in the curriculum. In that school year AE also offered its first two graduate courses related to engineering. One was in Aircraft Propulsion Systems, which studied "the theory and design of propellers and rotor blades" and included "a comparative study of propellers, rotor blades, and jet propulsion" (the first mention of jets in the curriculum). The other new graduate course was Advanced Aircraft Structures Design and covered the topics of "shear lag, thin plates and shells under buckling, plastic bending, shear web theory, and torsion in single and multi-cell structures and open sections."

In 1947 Edwards hired Charles B. Cliett, a native of West Point, Miss., as a member of the AE faculty. Cliett had enrolled at MSC in the early 1940s but then entered the Navy during the war and participated in the V-12 program. Cliett received his B.S. from the Georgia Institute of Technology in 1945 and then spent two years completing his obligation to the Navy (Barnett, p. 79). Shortly after his arrival Cliett was put in charge of constructing the department's first wind tunnel. This was an open-circuit tunnel built in one of several "temporary buildings" on campus erected to meet the needs caused by the influx of post-war students, many studying on the GI Bill. The first AE course in laboratory methods was offered in the 1947-1948 school year and concentrated on wind tunnel measurements.

The School of Engineering finally received its long-desired accreditation by the Engineers' Council for Professional Development (ECPD) in 1952. This was due in part to achievements brought about by Flinsch, to revisions in curricula suggested by prior ECPD visits, and to the construction of Patterson Engineering Laboratories, completed in 1950. This building provided 47,000 square feet of space for offices, shops, and laboratories (Haug, p. 91). The AE department received office and laboratory space in the building, and moved in as soon as it was dedicated. Cliett had gone on leave for the 1949-50 school year to obtain his M.S. degree from Georgia Tech, and upon his return in the summer of 1950 was immediately placed in charge of building the new AE wind tunnel in Patterson Lab. This wind tunnel was a closed-circuit wind tunnel with an octagonal test section 3 ft high, 4 ft wide, and 5 ft long. The top speed was 150 ft/s, and this facility is still in use today.

At about the same time that Cliett was busy building the department's subsonic wind tunnel, work was proceeding on the first supersonic wind tunnel facility in the department. William Huntington, one of the first graduate students in AE, began his M. S. work on a blow-down supersonic tunnel facility, citing in his thesis[4] the necessity of generating experimental results to "generalize" the many theoretical solutions to supersonic flow problems. According to his thesis[4], work had begun on this facility in 1949. The nozzle was designed using the methods outlined in Puckett[5]. The test section was 4 inches high, 1 inch wide, and 4 inches long, and the facility was driven by a compressed air tank with a capacity of 200 ft^3 and an operating pressure of 150 psi. The design Mach number of the facility was 2.21, but measurements based on schlieren photographs of the shock wave on a wedge indicated that the Mach number actually reached was only 1.62. The tunnel was completed by January of 1951.

The necessity of studying supersonic flows cited by Huntington also manifested itself in the AE curriculum. One of the new courses in the catalog for the 1951-52 school year was Aerodynamics of Compressible Fluids, to be taken in the senior year. This was the first separate course dealing with compressible flow in the curriculum and Edwards was listed as the instructor. Based on the course description, the textbook probably used was *Aerodynamics of Supersonic Flight*[6] by Cliett's instructor and colleague at Georgia Tech, Alan Pope. Some new graduate courses were also listed, including Aerodynamics of Supersonic Flow, taught by Edwards and most probably guided by Liepmann and Puckett's *Aerodynamics of a Compressible Fluid*[7]; Theoretical Aerodynamics – Perfect Fluids, taught by Edwards and Cliett; and Theoretical Aerodynamics – Real Fluids, taught by Edwards. The "perfect fluids" course dealt with "the basic ideas of wing theory as developed from classical treatises on hydrodynamics," whereas the "real fluids" course dealt with "the aerodynamics of viscous fluids; boundary layer, heat transfer, fundamentals of boundary layer stability, turbulence, the fundamentals of isotropic turbulence, and experimental methods." According to Barnett, the AE graduate program bore its first fruit in 1951, when three individuals received M.S. degrees in aeronautical engineering: Glenn D. Bryant, Joseph J. Cornish III, and William Huntington. Both Bryant and Cornish had been attracted to MSC by the idea of working with Raspet, and both continued working in the Aerophysics Department upon completing their M.S. degrees (Barnett, pp. 102-103). Cornish received the first Ph. D. granted by the School of Engineering in 1960.

The AE department received a new infusion of talent for the 1954-55 school year with the hiring of Leslie R. Hester. Hester had received his B.S. degree in AE from MSC in 1952 and gone to work for the EIRS on Raspet's ONR project (Barnett, p. 120). Upon completing his M.S. in AE in 1953, he joined the AE faculty. A new course, Aerodynamic Laboratory II, was added under Hester's instruction. This course dealt with aircraft performance measurements and aircraft stability and control. Indeed, by the 1955-56 school year, the areas of instruction seemed to have fairly well delineated between Edwards, Cliett, and Hester, with Edwards primarily responsible for aerodynamics, Cliett for structures, and Hester for flight mechanics. Hester taught the Aircraft Power Plants I & II courses (I dealt with internal combustion engines, II with jet propulsion) and both laboratory courses. Hester also assisted Cliett with the teaching of a new course, Vibrations and Flutter, which marked the first appearance of the discipline of vibrations as a separate course in the curriculum. In the 1957-58 school year, the senior design course was a two-semester course. The first semester dealt with topics such as layout, weight estimation, arrangement, balance, and performance estimation, while the second semester continued these topics through a detailed structural analysis of the wing. The next year, Hester's duties were extended further into the aerodynamics area when the graduate level viscous flow course was extended to two semesters, with Hester listed as the teacher for both. The first semester dealt with laminar flow, while the new second semester dealt with "the origins of turbulence; fundamentals of turbulent flow; turbulent boundary layers; turbulent flow through pipes; free turbulent flows; and determination of profile drag."

Smooth Sailing – and Rough

Raspet's early work in bird flight and associated soaring phenomena had already brought some recognition to MSC. However, in 1950, Raspet's research focus began to shift from bird flight to an area that would put Aerophysics and MSC squarely on the research map – boundary layer control (BLC). Raspet's early efforts in this area were in the promotion of natural laminar flow and the reduction of various surface roughness elements, such as gaps at panel edges or protruding fixtures, to decrease drag (Haug, p. 113). Efforts to produce natural laminar flow included the use of distributed suction, and the degree of success achieved warranted inclusion in the volume by Thwaites on incompressible flow[8]. In 1951, Raspet discovered another use of distributed suction: preventing separation of the boundary layer in large adverse pressure gradients. It was this discovery that would in Haug's words "shape the research program of the Aerophysics Department and provide it with its first national recognition for engineering research" (p. 114). Other researchers had experimented with boundary layer suction, but in those cases it was usually applied at a single location, usually through a slot. Raspet hit upon the idea of putting thousands of small holes in a wing surface and then using a small suction motor to pump air out of the interior of the wing. With this method applied to various aircraft, extremely large lift coefficients resulting in extremely small stall velocities could be obtained. The most dramatic results came when distributed-suction BLC was applied to an L-19 "Bird Dog" reconnaissance aircraft. The airplane could take off in 50 ft, had a minimum flight airspeed of 30 kts, and stalled at just 24 kts. Its maximum climb angle was 45 degrees and its maximum lift coefficient was 5. The potential for the application of this technology to STOL aircraft was obvious, and both the Navy and the Army were interested in pursuing this avenue of research.

Unfortunately for Raspet and the Aerophysics Department, support from MSC was almost exactly in inverse relationship to the progress made in research. During the initial formation of the Aerophysics Department, it had received strong support from MSC President Fred Mitchell. Mitchell's health began to fail, however, and by 1952 he had to be hospitalized in New Orleans. Most of his administrative duties fell to Benjamin Hilbun, his administrative assistant since 1949. Hilbun became acting president in 1953 and then president in 1954. Hilbun did not hold an advanced degree nor had he spent any of his working life outside of Starkville. Hilbun was not a supporter of research or the Aerophysics Department, and the budget allocated to the department by the college was cut from $32,000 in 1951 to $2,300 in 1952. By the time Hilbun retired in 1960, college funding had only been increased back to $3,400, even though during that time the Aerophysics Department had generated over $2 million in outside funding. The situation was so bad that when in the mid-1950s Bill Lear, out of gratitude for Raspet's efforts to improve the aerodynamics of Lear's *Lodestar,* offered a generous scholarship fund for research in Aerophysics, Hilbun turned him down (Haug, pp. 110-112). According to Barnett (p. 119), Hilbun had just rejected $100,000 per year in support of Raspet's research. The one bright spot in this period, from an administrative point of view, was that Raspet was formally named Head of the Aerophysics Department in 1953 (Barnett, p. 120).

The problems with funding did not end on campus. In 1954, Flinsch asked Graduate School Dean Herbert Drennon not to publicize the amounts of the contracts that Aerophysics had received from ONR. The fear was that if members of the board of trustees and state legislators friendly to the University of Mississippi found out, they would try to reduce the state's appropriation to MSC by the amount received from the ONR (Haug, p. 112). Flinsch himself did not last much longer. Shortly after his arrival at MSC, he had insulted Hilbun, who at that time was the college registrar. In 1957, now-President Hilbun called Flinsch into his office one day and summarily fired him (McKee, p. 72).

By 1957, Raspet had developed a proposal for an Aerophysics Institute to be built at Mississippi State at a cost of $500,000 and began attempting to obtain support for this proposal from outside sources, since it was obvious none was forthcoming from the college. This would take a few years. Meanwhile, research work continued and by 1960, according to Haug, "thirteen graduate students studying under Raspet and other faculty members associated with him had written master's theses on aspects of viscous flow, and researchers associated with Raspet's group had published seventy-four technical papers on sailplanes, fluid flow, and control of the boundary layer" (pp. 114-115). Joseph Cornish, David Murphree, Donald Boatwright, Cliett, and Bryant – all of whom would contribute significantly to the development of AE at Mississippi State – published papers or notes on aerodynamics and/or boundary layer control while working with Raspet (Haug, p. 115).

As fate would have it, 1960 was a traumatic year for both the Aerophysics Department and the Department of Aeronautical Engineering. In April of that year Raspet was demonstrating a Piper Super Cub equipped with BLC for Lowell L. Meyer, a representative of the

Chance-Vought Aircraft Corporation, when something went wrong, and the airplane crashed, killing both Raspet and Meyer. Harry Simrall, who had replaced Flinsch as Dean of Engineering, was in the state capitol lobbying for the Aerophysics Institute funding when he heard the news. The shocked Mississippi legislature voted soon afterward to approve the $500,000 in funding, and the Raspet Flight Research Laboratory opened its doors at the Starkville airport in the summer of 1964. Cornish was named director to succeed Raspet (Haug, p. 115, 117). Cornish had been working on his Ph. D. under Raspet and had completed writing his dissertation, which Raspet had read shortly before the crash. However, no one else was familiar with the results and so an outside review board was convened, eventually granting Cornish his degree, the first Ph. D. awarded by the School of Engineering (Barnett, pp. 158-159). Upon completion of the degree, Cornish was also named Head of the Aerophysics Department (Barnett, p. 163).

On October 18, 1960, AE department head Franklin "Tiny" Edwards suffered a massive stroke and died the next morning. Edwards had been one of the earliest students of AE at Mississippi State and had been on the faculty since 1941, except for the year he had taken off to get his M.S. at Caltech. According to numerous accounts, Edwards had helped Aerophysics through some of the difficult years in the 1950s. Charles Cliett, AE faculty member since 1947, was named the new department head.

A *MARVEL* to Behold

As discussed above, both the Navy and the Army were interested in STOL aircraft and in the application of BLC technology to such aircraft. Beginning in the mid-1950s Raspet and his group began an effort to develop a STOL aircraft which would combine several different technologies. The first step was the realization that the turbulent slipstream of a propeller on a standard tractor-type airplane contributed significantly to boundary layer separation on the wing and the conclusion that a pusher configuration would be more suitable. Next, since this was to be a STOL aircraft, a way had to be found to increase the static and low-speed thrust of the propeller. This called for the ducted fan approach. After considering the available aircraft, an Anderson Greenwood AG-14 pusher aircraft (serial number 4) was purchased in 1955. A ring duct was added around the propeller and flight tests were conducted to determine the changes in aircraft performance. It was found that the duct did in fact increase the static and low-speed propeller thrust, but it decreased thrust at higher speeds and added to the overall drag of the aircraft at higher speeds as well. It was decided to try to design the duct so that it could replace some other aircraft component by performing that component's function.

Next, the issue of BLC control was addressed. The idea was still to prevent separation of the boundary layer in large adverse pressure gradients. One way to avoid separation was to avoid disturbances to the flow, such as those created by flaps. Therefore, a variable camber wing was designed. A large crank inside the wing turned and distorted the wing surface, changing its camber and therefore producing a similar result to the deployment of a flap. By using a variable camber wing, a smooth wing surface could be maintained, without the joints, rivets, and other hardware that would be necessary for a wing and flap of standard construction. However, in order to have a flexible surface, the wing would have to be made of fiberglass instead of metal. Finally, distributed-suction BLC was also to be applied to the wing, to provide further protection against boundary layer separation.

The new airplane was designed under the Mississippi State *MARVEL* Program. The "*MARVEL*" acronym, which stood for "Mississippi Aerophysics Research Vehicle with Extended Latitude," was coined by Joseph Cornish. The Raspet group decided that in order to prove the concept and gain some experience, it would be wise to design and build a smaller, less powerful version of the proposed airplane. A second AG-14 (s/n 2) was acquired in January of 1957. The cockpit module, engine and landing gear were retained, but everything else was replaced. A new fuselage fairing was fitted around the cockpit. The fairing extended back to the tail, where the ducted fan was now located. The propeller was driven by a fiberglass extension of the engine driveshaft. The propeller shroud, a ring with an airfoil section, now served the function of the tail surfaces. Two articulated segments on the sides served as rudders, and four segments, two on the top and two on the bottom, served as elevators. The main wing had the variable camber mechanism and perforations for BLC. All of the fiberglass components were built by the Parsons Corporation of Traverse City, Michigan. This aircraft was dubbed the *Marvellette*, and in January of 1960 received the

U. S. Army designation XAZ-1, having been built under a contract with the Army signed in 1959.

The main drawback of the *Marvellette* was that it was overweight and underpowered. Tests were conducted with this aircraft until March of 1964, during which landing speeds of 31 kts were demonstrated. During this period work began on the primary aircraft, the actual *MARVEL*. The power plant of the new airplane was a 250 HP Allison T-63-A-5 turboprop. In its construction fiberglass was used almost exclusively, with stainless steel only used in selected areas for reinforcement, making the *MARVEL* the world's first all-composite aircraft. It had a wing span of just over 26 ft, a length of 23.25 ft, a wing area of 106 ft^2, and a maximum take-off weight of 1,890 lb. The first flight of the *MARVEL*, U. S. Army designation XV-11A, took place on December 1, 1965. Unfortunately, the BLC system did not provide enough suction to achieve maximum performance from BLC, and the expected results were not quite obtained. Nonetheless, a minimum take-off distance of 125 ft was demonstrated, as was a maximum lift coefficient of approximately 3.5.

Unfortunately for the *MARVEL*, external developments would intrude and cut short its usefulness as a research vehicle. During the 1960s the Department of Defense came under the direction of Robert McNamara, who brought a different perspective to defense spending, particularly on research. According to Haug (p. 117), McNamara directed each branch of the service to define itself in terms of its mission. To obtain funding, research projects had to be geared toward helping a service achieve its mission. By the mid-1960s, the Army's mission no longer required research on fixed-wing aircraft, and neither the Air Force nor the Navy wanted slow, STOL-type aircraft. Therefore, defense spending on STOL aircraft dried up, and the *MARVEL* project's funding was terminated in 1968, although flight testing would continue until 1970. An entire life cycle for research funding into STOL technology had come and gone.

Growing Our Own

The AE program underwent some fairly significant modifications beginning in 1960. For the first time the discipline of aircraft stability and control was separated out of aerodynamics and taught as a separate course in the 1960-61 school year. Also in that year the two aircraft power plant courses were dropped, and a single Internal Aerodynamics course, dealing essentially with jet propulsion, was substituted. Interestingly, Internal Aerodynamics was one of three electives that could be chosen, along with Structural Dynamics and another structures course, meaning that no aircraft propulsion course was *required*, a situation which continued for several years. Graduate courses in Applied Elasticity, Advanced Strength of Materials, and Elastic Stability were added.

In 1962 the department's name was changed to the Department of Aerospace Engineering. All courses now carried an "AsE" prefix (now "ASE"). The name change reflected the addition of two new courses related to space: Space Mechanics, and Propulsion Systems, which dealt primarily with rockets. Both of these new courses were taught by Hester. In 1959, Associate Professor Walter Carnes joined the ASE faculty. Carnes, who had received his M.S. from Georgia Tech, left in 1961 for the University of Illinois, where he received his Ph. D. in Mechanics in 1963, and then returned to MSU. In the 1964-65 school year, the courses of statics, dynamics, mechanics of materials, fluid mechanics, and vibrations were listed for the first time as engineering mechanics (EM) courses, separate from any particular department. There was some thought at the time of establishing a separate EM department, but that did not take place, although the separate EM courses would remain. The 1964-65 school year was significant also in that the School of Engineering had become the College of Engineering of Mississippi State University. The ASE department began offering a two-semester senior design sequence, but that would be short-lived.

When Charlie Cliett became department head in 1960, he was soon confronted with the difficulty of recruiting faculty with advanced degrees to Mississippi State, which had become a university in 1957. Cliett realized that the department's best chance of obtaining talent was to identify promising graduates and graduate students, hire them as lecturers for a year or two, and then send them off to obtain their Ph. D. degrees, supplementing their stipends and promising them jobs when they finished. Cliett was able to recruit a few notable faculty members in this way. His summation of the situation was "we have to grow our own."

The 1960s saw the growth of the experimental facilities of the ASE department. In 1963, A. George Bennett, Jr. returned to MSU after completing his M.S. at the University of

Illinois. Bennett had acquired his B.S. in ASE from MSU in 1959 and had gone to work for Douglas Aircraft in Long Beach, CA. Cliett recruited Bennett to get his M.S. and then come to MSU as an assistant professor. When Bennett arrived at MSU, his first assignment was to oversee the assembly of a large supersonic tunnel that had been donated to ASE. This was a blow-down tunnel with a 9 in by 18 in test section that had been used in a structures group at NASA Langley Research Center for flutter testing. The components included a settling chamber, nozzle blocks for Mach numbers between 1 and 5, and a vacuum sphere with a capacity of 5,500 ft^3. The only component missing was a high-pressure tank, and this was constructed by Babcock and Wilcox, the steam boiler manufacturers, who had a plant in West Point, Miss.. The new tunnel was located in Patterson Laboratories, with the tank standing just outside the back door.

The supersonic tunnel took its place alongside another new facility in Patterson Lab, a high-speed water tunnel facility designed and built by Aerophysics graduate student Graham Wells[9]. Wells toured 19 different water tunnel facilities in North America and Europe before building the MSU tunnel, constructing it from fiberglass. It had an 11-inch diameter test section, a 13.2:1 contraction ratio, and was designed for a top test section speed of 75 ft/s. Because of the power requirements for such a large speed, the first power plant for the water tunnel was a 250-HP Buick V-8 car engine. The tunnel may have been one of the few in the world with a gear shift, mounted on a tunnel support just downstream of the test section. Subsequent modifications included replacing the V-8 with an electric motor that reduced the top test section speed to 50 ft/s.

Another of Cliett's early recruits made a significant impact on MSU's aeronautical engineering program almost immediately on his return. David Murphree had worked as an undergraduate for the Raspet group until he completed his B.S. in AE in 1960. When he left to get his graduate degrees, Cliett promised him a job if he came back. Murphree completed his Ph. D. in physics at the University of Wisconsin in 1965 and did return to MSU. His presence was felt almost immediately, as new courses in Fundamentals of Plasma Dynamics, Hypersonic Aerodynamics, and Magnetoplasmadynamics sprang up almost overnight. These courses reflected Murphree's interest in the subject of re-entry flows, as did one of his early research projects. In 1966 Murphree received a National Science Foundation (NSF) Research Initiation Grant for the study of plasmas and aerodynamic processes occurring in an arc-driven, hypersonic plasma tunnel, along with the development of the necessary instrumentation[10]. According to the first annual report for this grant, the work was divided into six areas, with the first three being related to the assembly of a Mach 12 plasma tunnel system that had been donated to the department. This was a small hypersonic facility that had a 7-inch diameter, 10-inch long test section that was to be used in general to study problems of hypersonic aerodynamics, and in particular to study variable-area diffusers for use in Mach 12 flow[11]. This facility made use of the vacuum sphere that had come with the supersonic wind tunnel. The other three areas covered by the NSF grant were related to fundamental properties of plasma flows, including the determination of the velocities of such flows. Research in the hypersonic tunnel did not proceed very far, but the work done in preparing for its use, both in hardware and in theoretical development, would pay off significantly in a few short years.

Murphree was not the only new faculty member with new courses. In 1961 Joe F. Thompson received his B.S. in physics from MSU. In 1963 he completed an M.S. in ASE, working at RFRL under Cornish on the problem of turbulent vortex structure. After working on the Apollo program for NASA in Huntsville for just over a year, he was hired as an assistant professor in ASE in 1964, the third of Cliett's recruits. Thompson introduced two graduate courses for the 1966-67 school year: Compressible Viscous Flow, and Aerothermochemistry, which was essentially a course in combustion.

The 1960s saw a number of important additions to the ASE curriculum. A graduate course in Advanced Guidance and Control of Aerospace Vehicles had been added for the 1965-66 school year. In the 1968-69 school year, first-semester juniors were required to take IE 1111 Computer Programming – the first appearance of FORTRAN in the ASE curriculum. The three-hour laboratory course was taught for the year by the Industrial Engineering (IE) department. The next year it was moved to a new Department of Computer Science and was given the designation CS 1011, a number it carried for several years. It was also moved to the first semester of the sophomore year in ASE. The 1968-69 school year also saw the renaming of Space Mechanics to

Astrodynamics I and the addition of a new graduate-level Astrodynamics II course. In the 1969-70 school year a course in Fundamentals of Rotary Wing Analysis was taught for the first time. The establishment of this course paralleled research on helicopter aerodynamics being conducted at RFRL, primarily under Donald Boatwright. Boatwright made helicopter propeller downwash measurements that are still used in standard helicopter texts today[12, 13].

Tailspin and a Calculated Recovery

As can be seen from the history of the departments to this point, Aeronautical/Aerospace Engineering and Aerophysics had separate beginnings. During the early years of Aerophysics, the relationship between the two entities was fairly informal. Aeronautical engineering would supply faculty to assist with Aerophysics research as needs arose, and graduate students in aeronautical engineering would do their research on Aerophysics projects. As noted above, Edwards as head of AE had helped out Aerophysics financially from time to time. In the late 1950s, steps were taken to make the relationship between the two units more formal. In 1959, Raspet, Cornish and Bryant were named research professors of aeronautical engineering (assistant research professors in the cases of Cornish and Bryant), and Edwards, Cliett and Hester were named associates of the Aerophysics staff (Barnett, p. 143). Upon Raspet's death in 1960, Cornish was named director of the flight laboratory and then head of Aerophysics upon the completion of his Ph. D.. However, Cornish left in 1964 to begin a long and distinguished career with Lockheed. The directorship of the RFRL fell to Sean Roberts, who was acting head of Aerophysics until 1967, when Aerophysics and ASE were merged into a single department, the Department of Aerophysics and Aerospace Engineering. Cliett was head of the combined department, and Roberts remained as director of RFRL and Research Professor of Aerophysics and Aerospace Engineering.

The year 1969 was a high point in aerospace engineering around the country. Armstrong and Aldrin walked on the moon. Unfortunately, the decline in aerospace engineering after that peak, both nationally and at MSU, was extremely sharp. As noted earlier, the redirection of research funding by the military ended the *MARVEL* project in 1970. The end of the Apollo program in 1971 marked the beginning of a massive decline in the aerospace industry, a decline reflected in ASE enrollment at MSU and around the country. The year 1971 also saw the resignation of Sean Roberts as director of RFRL. Thus both ASE and RFRL found themselves at perhaps the lowest points in their histories. By this point the ASE faculty had grown rather large, too large to be supported by the student enrollment in ASE at the time. RFRL had little external support and certainly not enough to maintain its operation. Cliett convened the ASE faculty and presented them with two options: begin generating funded research or see the ASE department reduced greatly in size, if not eliminated altogether. The faculty eventually decided to concentrate on three areas: general aviation research to be carried on at RFRL; magnetohydrodynamics (MHD), a promising area being pursued by the group headed by David Murphree, and a relatively new area – computational fluid dynamics, or CFD, under the direction of Joe Thompson. (Haug, p. 122).

Thompson had returned to MSU after completing a Ph. D. in CFD at Georgia Tech in 1970. Thompson's efforts soon paid off. In 1974, Thompson and ASE graduate student Frank C. Thames, along with MSU mathematics professor C. Wayne Mastin, published the first work in the area that would put MSU on the CFD map – numerical grid generation[14]. Thompson and the others discovered a method for distributing the grid points in a boundary-conforming grid that made use of the solution of an elliptic partial differential equation. This was a major breakthrough in CFD technology and would lead to the publication of the first textbook in the area of numerical grid generation[15], co-authored by Thompson, Mastin, and Z. U. A. Warsi, a graduate of the University of Lucknow in India who joined the ASE faculty in 1971 after working for four years as a researcher at RFRL. Warsi would become one of the most prolific authors in the department and would eventually publish a graduate-level textbook on fluid mechanics[16]. The breakthrough in numerical grid generation would also lead to numerous short courses and other conferences that would draw attention to the CFD work being done at MSU and would attract other researchers in the area. The first course in Numerical Fluid Mechanics at MSU was offered by ASE in the 1973-1974 school year.

Prior to Thompson's return, another of Cliett's recruits, George Bennett, came back to MSU in the fall of 1969 after completing his Ph.

D. at the University of Illinois. At Illinois Bennett had been a classmate of Bob Liebeck, who was doing his dissertation work on inverse-design techniques for high-lift airfoil sections. Shortly after his return to MSU, Bennett began a course on Applied Airfoil and Wing Theory, which made use of the methods developed by Liebeck and others for airfoil and wing design in incompressible, subsonic, and supersonic flows. Bennett also instituted a course in Advanced Performance which dealt with advanced aircraft configurations and advanced performance analysis techniques.

The last of Cliett's recruits returned in 1969. John C. McWhorter, III had received his B.S. in mechanical engineering from MSU in 1964. He had then obtained an M.S. in ASE in 1965, performing wind tunnel and flight research under Sean Roberts. After teaching engineering mechanics courses at MSU for a couple of years, McWhorter left to obtain his Ph. D. in Mechanics at the University of Illinois, in the same program where Carnes had obtained his Ph. D. a few years before. When McWhorter returned to MSU, he was listed in the catalog as a member of the ASE faculty, but his individual listing in the catalog referred to him as Assistant Professor of Engineering Mechanics. McWhorter taught mechanics courses and ASE structures courses for several years and in August of 1979 became coordinator of the engineering mechanics (EM) program at MSU. ASE and EM had always been connected, with the direction of the EM program being housed in ASE. In the 1970s, however, Cliett took steps to make the connection more formal, giving ASE primary responsibility for teaching the EM courses and thus providing ASE with a larger enrollment base. This was another example of Cliett's skill in protecting ASE during the dark days of the 1970s.

That engineering students shall take thermodynamics is a maxim of almost biblical proportions, and ASE students were no exception. For many years ASE students had taken the ME thermodynamics course. However, the long-recognized fact that most ASE graduates did not need a working knowledge of the steam tables, but many did need a deeper understanding of compressible flow, was acted upon in the mid-1970s. In the 1975-76 school year, a new course called Gas Dynamics was introduced, replacing the ME thermodynamics course. The content of Gas Dynamics was very similar to the thermodynamics course just removed, and was in fact about four-fifths classical thermodynamics and one-fifth compressible flow. The new topics were an introduction to isentropic compressible flow, flow through converging-diverging nozzles, and normal shocks, preparing the students for more advanced studies later in the curriculum when they took Compressible Aerodynamics. The Gas Dynamics course is significant in that with its adoption, the ASE curriculum took on the form that it would keep for close to twenty years, with very few changes. Students started with two years of calculus, two semesters of chemistry, two semesters of engineering graphics, and three semesters of physics. They took the engineering mechanics courses of Statics, Dynamics, Mechanics of Materials, Fluid Mechanics, and Vibrations, along with Gas Dynamics and the FORTRAN course discussed earlier. These were followed (or in some cases paralleled) by a three-course sequence in flight mechanics (Performance, Static Stability and Control, Dynamic Stability and Control), a three-course sequence in aerodynamics and propulsion (Incompressible Aerodynamics, Compressible Aerodynamics, and Propulsion), and a three-course sequence in structures. Two lab courses and a one-semester Systems Design course, along with three technical electives, an ME heat transfer course, a couple of math courses and a number of humanities courses, completed the ASE undergraduate degree requirements.

David Murphree's efforts in developing expertise in high-energy flows paid off in the mid-1970s. In 1976, Mississippi State University was selected by the federal Energy Research and Development Administration, a product of the Arab oil embargo of the early 1970s, as a research center for magnetohydrodynamic (MHD) technology, along with the University of Tennessee Space Institute, the Massachusetts Institute of Technology, and Stanford University. Early on the MSU group discovered its niche when Murphree and W. Steve Shepard, a 1967 addition to the ASE faculty, realized that the best way to determine the composition of the high-temperature, high-energy gases in the MHD facilities was to use laser spectroscopy as a non-intrusive diagnostic tool. The development of instrumentation for studying MHD flows became the focus of efforts at MSU. By 1980, the U. S. Department of Energy had provided over $4 million in funding for MHD research, the largest amount received to that time for a research project. In 1980, the MHD Energy Center was organized as a separate unit that reported directly to the director of EIRS. Murphree and Shepard became the director and associate director, respectively, effective January 1, 1980. All of the employees in the ASE department who were being funded by the DOE contract for MHD work were transferred to the MHD Energy Center. In 1985, Murphree left the university to found the Institute for Technology Development, a state-wide effort that was funded by a $20 million grant from the state of Mississippi. Shepard was named Director of the MHD Center. Later the MHD Center at MSU would change its name to the Diagnostic Instrumentation and Analysis Laboratory, or DIAL (Haug, p. 123; McKee, p. 144).

In 1978, one other significant change in the ASE program took place. Since the merger of Aerophysics with Aerospace Engineering in 1967, the department had been known as the Department of Aerophysics and Aerospace Engineering. In 1978, department head Cliett wrote a letter to university president James McComas, petitioning that the name be changed to the Department of Aerospace Engineering. Cliett pointed out that RFRL had acquired a national reputation of its own, without a direct tie to "Aerophysics" as such. The one-page letter, which essentially served as the application and approval form, carried the signatures of Cliett, Willie L. McDaniel, director of EIRS; Harry Simrall, Dean of Engineering; J. C. McKee, Vice-President for Research and Graduate Studies; Robert E. Wolverton, Vice-President for Academic Affairs; and James D. McComas, President of the university. The change took effect July 1, 1978. While the RFRL would certainly perpetuate the memory of August Raspet in a manner befitting his efforts, the last vestige of the separate department that Dean Flinsch had created so that Raspet could conduct his research unimpeded had been removed.

The *MARVEL* Becomes a Phoenix, and the Computational Feature

In 1974, Ernest J. Cross, who had acquired his Ph. D. from the University of Texas in 1968 and worked at the U. S. Air Force laboratories at Wright-Patterson AFB, became director of RFRL upon his retirement from the Air Force. During his tenure as director, RFRL was involved in tip vortex research for NASA using a Cessna AgWagon and in cooling drag measurements on a Navy T-34B trainer, among other projects related to general aviation. After Cross left to become head of the Department of Aerospace Engineering at Texas A&M University in 1979, he was succeeded as director by George Bennett (McKee, p. 109). Bennett oversaw a new study of BLC performed for Lockheed. The effects of spanwise blowing on boundary layer separation were studied on a Caproni sailplane equipped with a small jet engine that extended its time aloft. The blowing increased the maximum lift coefficient at high angles of attack. The glider was also used for laminar flow research using a "glove" in the shape of a natural laminar flow airfoil attached to the wing of the glider (Haug, p. 125).

Following completion of its flight testing in 1970, the *MARVEL* had been placed in storage. In 1981, however, it was returned to service when RFRL received a contract from Brico Limited to perform research on a desert utility observation aircraft. The requirements were that the aircraft be able to take off from sand and possess low infra-red and radar signatures. The *MARVEL* seemed to be an ideal candidate, having been designed as an STOL aircraft. However, some significant modifications were required. Because of the BLC and variable camber technology applied to the wing, there was no room for fuel inside the wing, and so as originally constructed the airplane's fuel tank was small, thus limiting the range of the aircraft – and was located under the pilot's seat. It was also recognized that suction BLC would not work very well in a sandy climate. For these reasons a completely new wing was designed and built in a very short time. The spar was constructed from fiberglass in New Mexico, the wing skins were built of Kevlar in Florida, and the wing was assembled at RFRL. The airplane was tested in Saudi Arabia in 1982, where it was determined that the landing gear design was not appropriate for sand operations.

Even though the *MARVEL* test was not completely successful, it opened the door for new efforts at RFRL. From the beginning RFRL had been involved in constructing structural components from fiberglass. With each new project, expertise in this area grew. After Bennett became director of RFRL, efforts in the area of fiberglass construction and the more general area of composites were increased. In particular, the work concentrated on rapid prototyping, which consisted of constructing molds using computer-controlled milling machines and then using the molds to fabricate components from composite materials such as fiberglass. These efforts were rewarded in 1986 when the Honda Research and Development Corporation began a program at RFRL to develop a turbojet-powered aircraft constructed completely from composite materials. The project began with the replacement of the horizontal stabilizer and rudder on a Beechcraft A-36 with new components built from composite materials. Later the main wings were also replaced. Finally, a completely new aircraft with twin turbojet engines mounted on top of a high-wing configuration was completed at the end of 1992 and flight-tested in 1993. The airplane was constructed in a new building built by Honda at RFRL and called the Honda Annex. At the end of the testing program, the building and a Rockwell Turbo Commander twin turboprop, used as a chase plane for the Honda projects, were turned over to the university. By the end of their 10 years at MSU, Honda had been the source for over $16 million in research and development funds. During the years of the Honda project, work at RFRL on rapid prototyping continued and efforts at nondestructive testing and evaluation of composite structures using acoustic techniques were initiated. The composite materials fabrication capabilities were exercised in an unusual fashion in 1991, when the senior design class designed and built a one-third replica of the National Aerospace Plane, or NASP. The 30-foot long model was completed in one semester, on the day it was scheduled to be shipped to Oshkosh for its premier.

Joe Thompson's response to Cliett's challenge would also be rewarded. In January of 1981, David Whitfield joined the CFD efforts at MSU. Whitfield was a noted CFD researcher who came to MSU from the Arnold Engineering Development Corporation (AEDC) at Tullahoma, TN. While research in CFD was going on in ASE, work in designing integrated circuits for specific applications was being done in the Department of Electrical Engineering at MSU, under the direction of Donald Trotter. These two efforts were merged into one when in 1987 the Air Force Office of Scientific Research provided $5 million to establish the Research Center for Advanced Scientific Computing at MSU (Haug, p. 124). The purpose of RCASC was twofold: the CFD group would develop codes to solve the equations of fluid mechanics, and the digital circuits group would develop computer chips that were "hard-wired" to run the CFD codes. RCASC as a separate entity would be short-lived, however. In 1988 Thompson, Whitfield and Trotter submitted a proposal for a National Science Foundation Engineering Research Center. The decision to fund the center was announced in January of 1990, and the center became the NSF Engineering Research Center for Computational Field Simulation, one of only 19 similar institutions around the United States. The new center was dedicated on May 10, 1991, with Joe Thompson as the founding director (Haug, p. 125).

The standard life cycle of an NSF ERC was 11 years. After the end of that period, the Center was to become a stand-alone operation, no longer dependent on NSF funding. During its 11 years under the NSF umbrella, MSU's ERC saw an enormous increase in CFD work. Bharat Soni, a noted researcher in the area of unstructured grid solutions, joined the ASE faculty as an ERC researcher. Dave Whitfield established the Simulation Center, a group within the ERC that developed new flow solvers and applied them to complicated geometries. Much of the SimCenter's work was funded by the Office of Naval Research. Work on very large scale integrated circuits (VLSI circuits) also continued, although breakthroughs in parallel processing technology meant that chips hard-wired to solve fluid mechanics problems were no longer necessary. Other work, particularly research in scientific visualization and the graphic display of data, became important components of the ERC's efforts. Periodic reviews of the ERC by the NSF regularly commented on the quality of the work done at the ERC and how well the ERC was operated.

Changing of the Guard

In 1991, two veterans of the ASE department, Charles Cliett and Leslie Hester, retired. At the time of his retirement, Cliett had served the department for almost 43 years, 31 of them as department head. He had certainly left his mark on the department. Three of his "recruits" had become directors of research units: Murphree, who was the founding director of the MHD Center, later DIAL; Bennett, who became head of RFRL; and Thompson, founding director of the ERC. The fourth recruit, McWhorter, became interim department head upon Cliett's retirement and was later named department head. There is no doubt that Cliett had an eye for talent, and the dramatic increase in the research output of the department, reflected in the growth of work at RFRL and the establishment of the MHD Center / DIAL and the NSF ERC, demonstrate well his abilities of motivation. Hester's contributions had been numerous, and the continued operations of the various ASE facilities in Patterson Laboratories were due in very large part to his efforts.

After a successful ABET accreditation visit in the spring of 1993, McWhorter embarked on a major revision of the ASE curriculum. As discussed before, the curriculum had really not seen much modification since the mid-1970s. The review of the program was motivated in large part by the downturn in ASE enrollments that began in the early 1990s and rivaled the downturn of the 1970s in its severity. The magnitude of the decline can be understood by a look at the enrollments in Flight Mechanics I – Aircraft Performance. This course was the first ASE course ASE students took, in the second semester of the sophomore year. In 1992 enrollment in Flight I peaked at 50 students. The enrollments for the following years tell the story: 1993, 25 students; 1994, 12 students; 1995; 6 students. McWhorter and the faculty realized that dramatic steps needed to be taken to make the program attractive to students both in Mississippi and around the country, if it were to survive. It was recognized that the department possessed unique resources in RFRL and the ERC, and that it needed to figure out ways to incorporate these resources into the curriculum.

The faculty began looking closely at both individual courses and the curriculum as a whole. One deficiency that had been noted for a number of years was the lack of contact with students early in their programs. As just stated, the first ASE course was not taken until the second semester of the sophomore year. The necessity of establishing a relationship with students early on was recognized as a key to student retention. Therefore a three-semester Introduction to Aerospace Engineering sequence, beginning in the first semester of the freshman year, was established. This course had multiple purposes. In addition to introducing students to basic concepts of aerospace engineering, it was also designed to teach basic computer skills, such as word processing and spreadsheets, use of mathematical toolkits such as Mathcad, and proficiency in Unigraphics, a computer solid modeling and analysis program. This sequence thus replaced the traditional Engineering Graphics classes that had been in the curriculum since the beginning (the FORTRAN course had been dropped as a requirement a few years earlier). In order to make room for the third semester, the course in Performance was dropped, but the material was included in the freshman sequence. Other courses were revised to make use of the skills acquired by the students in the freshman sequence. Another course that was dropped was the ME heat transfer course that had also been part of the curriculum for a number of years. This course was removed to decrease the total number of hours required for graduation. The Gas Dynamics course was modified to include an introduction to heat transfer and was renamed Aerothermodynamics. The placement of other courses in the curriculum was changed, with both the structures sequence and the laboratory course sequence beginning a semester earlier. Finally, a new two-semester design course was put together and will be taught for the first time in the fall of 2003. In addition, new recruiting efforts were begun. The *MARVEL* was pressed into service once again, this time as a traveling static display and attention-getter that was carried all the way to the annual fly-in at Oshkosh. Along the way, ASE enrollments began to recover, with approximately 25 students currently in the junior level courses, the largest such enrollments since 1992.

The end of the 1990s and the beginning of the 21st century saw further turnovers in personnel. In 1997 Shepard retired as the director of DIAL, around the time of the completion of its new 55,000 ft^2 building, funded by \$8 million in grants from the Department of Energy and the state of Mississippi. At the time of his retirement, MHD/DIAL had received over \$70 million in research funding since its inception in 1976. RFRL celebrated its 50th anniversary in 1999. Bennett retired as director of RFRL and ASE faculty member in 2001 and was succeeded by David Lawrence, formerly CEO of Tracor Flight Systems and a former associate director of RFRL. In the summer of 2002 the department was racked by a number of departures. Bharat Soni left the ERC to pursue opportunities at the University of Alabama at Birmingham. Dave Whitfield, along with ME faculty member Roger Briley and a number of research personnel from the ERC, left to start a new simulation center at the University of Tennessee at Chattanooga. Four other ASE faculty members were offered positions at UTC, but chose to remain at MSU. A major impact of the departures of Whitfield and Soni from ASE was financial, since both had brought in significant research funding and had also provided significant released-salary and overhead funds. Then, also in the summer of 2002, MSU offered an early retirement option, and McWhorter and Warsi chose to exercise this option. Because of budget cutbacks at the university, these faculty members could not be replaced immediately. In very short order ASE had lost four faculty members and was in significant danger of losing the positions as well. Boyd Gatlin, who had joined the ASE faculty after completing his Ph. D. in CFD in 1987 under Dave Whitfield, became the interim department head. Since being named interim head, Gatlin has instituted a number of efforts aimed at preserving the ASE department. A search for a new permanent department head is currently underway.

Conclusions

The history of aerospace engineering at Mississippi State University has seemingly followed a cycle of crisis and exertions to survive the crisis that has appeared to repeat itself every ten years or so. There were the initial struggles to survive in the early 1930s, followed by the difficulties of the war years in the mid-1940s. The mid-1950s saw the problems in funding faced by Raspet with the university administration. The cycle then shifted slightly, with the next crisis coming in 1960 with the deaths of Raspet and Edwards. The early 1970s saw the near-demise of RFRL and the department because of declines in research funding and in enrollment, followed by a similar crisis in the early 1990s. Each time the department has responded with renewed effort, rising to the challenges and overcoming the obstacles. The first years of the 21st century have brought their own challenges, with significant faculty retirements and departures and the lack of the immediate ability to replace all who have left. It is to be hoped that those of us who currently comprise the ASE faculty at Mississippi State University will respond as our forerunners did, with equal amounts of imagination, inspiration, and determination.

Note on Sources

In 1992 C. James Haug wrote a history of the College of Engineering at MSU for its centennial celebration[1]. In 2001, Cory Barnett wrote a master's thesis in history on the first 27 years of the ASE department[2]. In 2002, Chester McKee, a former MSU electrical engineering faculty member and the first Vice-President for Research at MSU, published a second history of engineering at MSU that consisted primarily of his personal recollections[3]. These three works provided significant contributions to this article. In an attempt to give these authors reasonable credit for their works and to also keep the reference list manageable, the author has made use of the author/page citation method in the text for these three works. All of the rest of the references are cited in standard endnote format. The author would like to thank the current and former members of the ASE faculty for their assistance in providing information and in reviewing the text, in particular Charles Cliett, George Bennett, Joe Thompson, and John McWhorter. The author was privileged to study under these individuals in the early 1980s and then to serve alongside them beginning in 1993, and is grateful for their contributions to his professional development.

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Figures

Fig. 1 Kenneth Withington, first head of Aeronautical Engineering, 1933-1946

Fig. 2 August Raspet

Fig. 3 L-19 Boundary Layer Control Research Aircraft

Fig. 4 *Marvellette* STOL Research Aircraft

Fig. 5 The *MARVEL*

Fig. 6 Raspet Flight Research Laboratory

Fig. 7 Charles B. Cliett, Department Head, 1960-1991

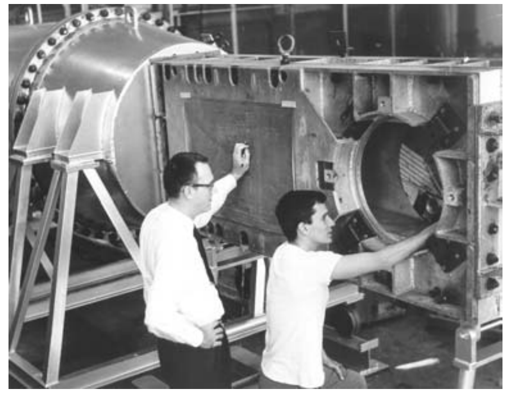

Fig. 8 George Bennett (left) oversees assembly of supersonic wind tunnel, ca. 1964

Fig. 9 Students working in the subsonic wind tunnel in the 1970s

Fig. 10 The Honda Jet, with the Honda Annex in the background

Fig. 11 The Honda Jet in flight

Fig. 12 MSU Engineering Research Center

Fig. 13 Diagnostic Instrumentation and Analysis Laboratory (DIAL)