AIAA-2003-0234

History of Aerospace Education and Research at Purdue University: 1910 – 2002

A. F. Grandt, Jr. and W. A. Gustafson
Purdue University
W. Lafayette, IN

41st Aerospace Sciences Meeting & Exhibit
6-9 January 2003
Reno, Nevada

HISTORY OF AEROSPACE EDUCATION AND RESEARCH AT PURDUE UNIVERSITY: 1910 - 2002

A. F. Grandt, Jr., AIAA Fellow, Professor

and

W. A. Gustafson, Professor Emeritus

School of Aeronautics and Astronautics, Purdue University, 315 N. Grant Street, W. Lafayette, IN 47907-2023

Abstract

This paper summarizes how Purdue University has developed into one of the world's leading institutions of aerospace education and research. It is estimated that during the past fifty years, Purdue has awarded 6 % of all B.S. degrees and 7 % of all Ph.D.'s in aerospace engineering in the United States. These alumni have led significant advances in research and development, headed major aerospace corporations and government agencies, and have established an amazing record for space exploration. Over one third of all U.S. manned space flights have had at least one crew member who was a Purdue graduate (including the first and last men to step foot on the moon), and a fourth of all U.S. space missions have been flown by a graduate from the School of Aeronautics and Astronautics.

Early History

Although it may surprise some that a small community in northwest Indiana has played a leading role in developing air and space travel, the Lafayette area has a long tradition with exploring the frontiers of human progress. Just a few miles southwest from the current Purdue campus, Fort Ouiatenon was established as a French trading post with the Wea Indians in 1717, and became an important center for the Indian and white man to exchange respective cultures and technologies. The fact that these interchanges were not always peaceful is also evident in local history, as the Battle of Tippecanoe occurred a few miles northeast on November 7, 1811. This was the last large conflict between organized Indians and white men east of the Mississippi River, and was a milestone in bringing peaceful settlement to the Northwest Territory.

The Lafayette area also has a rich aerospace tradition. It was, for example, site of the first U.S. airmail delivery on August 17, 1859, accomplished by a hot air balloon piloted by John Wise of Lancaster, Pennsylvania, and directed by U.S. postmaster Thomas Wood of Lafayette [1]. This first airmail consisted of 123 letters and 23 circulars, and traveled approximately 25 miles before the balloon was forced to land from lack of buoyancy. Mr. Wise also conducted experiments during this short flight to measure the presence of ozone in the upper atmosphere. Thus, 10 years before Purdue University's founding in 1869, Lafayette already had a history of experimentation with air travel and with using that new technology for scientific exploration.

Community interest in aviation continued when Purdue was established across the Wabash River in what was to become West Lafayette. The Purdue Aero Club was organized in 1910 under the direction of Professor Cicero B. Veal of mechanical engineering, and the community's first aircraft demonstration was held on the campus June 13, 1911 (Figure 1). Sponsored by the Purdue Alumni Association and a local newspaper, this "Aviation Day" attracted 17,000 people to see two flimsy biplanes land on the Purdue athletic field [1,2]. Other flights to campus in the next few years continued to draw large crowds (Figure 2).

The first Purdue graduate to become an aviator was J. Clifford Turpin (class of 1908), who was taught to fly by Orville Wright. Turpin set an altitude record of 9,400 feet in 1911, establishing an alumni tradition that was continued 55 years later, when an X-2 aircraft flown by Captain Iven C. Kincheloe (BS '49) flew to 126,000 feet in 1956. (That record was subsequently surpassed by alumni Neil A. Armstrong (BS '55) and Eugene A. Cernan (BS '56) during their 1969 and 1972 flights to the moon.) Lieutenant George W. Haskins was the first alumnus to land an aircraft on campus in 1919, when he flew from Dayton, Ohio with a resolution from Dayton alumni proposing that Purdue establish a School of Aviation Engineering [1].

Purdue began limited education in aeronautical engineering during the 1921-22 academic year with four elective courses offered by the School of Mechanical Engineering. Professor Martin L. Thornburg, a 1915 ME graduate and veteran of the Air Service, was in charge of instruction [1]. An aerodynamics laboratory was soon established and equipped with a fully assembled airplane and operating engines (Figure 3). When Professor Thornburg left in 1924, responsibility for the new aeronautical courses was given to Professors Elbert F. Burton and Alan C. Staley. They were later followed by Major William A. Bevan of the Air Service in 1926, and by Captain George Haskins in 1929 (Figure 4). Although a formal four-year aeronautical curriculum was not available until the 1940's, many civil and mechanical engineering students took the aeronautical electives, commonly referred to as the senior aeronautical option, and entered the new aeronautical industry during the 1920's and 30's. Donovan R. Berlin (BS '21) is one early graduate who designed a number of important aircraft during the first half of the 20th century, including the P-36, P-40, and P-48 of WW II fame. He later worked on the Navy's FH-1 Phantom and the Army's CH-47 Chinook helicopter, and was awarded an honorary doctorate by Purdue University in 1953 for his significant contributions to the aircraft industry.

Purdue became the first U.S. university to offer college credit for flight training in 1930, and opened the nation's first college-owned airport in 1934 [1,2]. Although somewhat controversial among faculty, the concept of providing academic credit for flight training was actively promoted by Purdue President Edward C. Elliott. President Elliott was later responsible for bringing Amelia Earhart to Purdue as a "Counselor on Careers for Women," a staff position she held from 1935 until her disappearance in 1937 (Figure 5). Purdue was instrumental in funding Earhart's ill-fated "Flying Laboratory," the Lockheed Electra that she attempted to fly around the world in 1937. The University library houses an extensive Earhart collection, which continues to be studied by those seeking to solve the mystery of her final flight.

Active involvement in flight training continued during the 1930's, and Purdue was an important military flight-training center during World War II. Training of aviation technicians was started in 1954 and a two-year professional pilot program was created in 1956. A general aviation flight technology course was created in 1964, and a B.S. program in professional piloting approved in 1964. These pilot training and aircraft maintenance programs continue in the current Department of Aviation Technology. The focus of this paper, however, is on Purdue's aerospace engineering programs.

Professor Haskins returned to the Air Corps in 1937, and the aeronautical engineering programs were taken over and expanded by three key individuals: Professors Karl D. Wood (Figure 6) and Joseph Liston (Figure 7) who joined the faculty in 1937 and by Professor Elmer F. Bruhn (Figure 8) in 1941. Professor Wood came to Purdue after many years at Cornell University, where he had published a comprehensive book on airplane design in 1934 [3]. Professor Wood was a strong advocate of education that balanced theory, technical analysis, testing, and design, and although he left Purdue in 1944 to head the Aeronautical Engineering Department at Colorado University, his seven-year tenure left a permanent imprint on Purdue. Professor Liston remained for 35 years until retiring in 1972. He was responsible for developing excellent propulsion courses and laboratories.

Professors Wood and Liston strengthened and expanded offerings in theoretical aerodynamics, airplane design, and aircraft engine design. A weakness in the structural area was ably addressed by recruitment of Professor Elmer F. Bruhn in January of 1941. Professor Bruhn taught 5 years at the Colorado School of Mines, followed by 12 years in industry with the North American Aviation and Vought-Sikorsky Aircraft Companies. One of Professor Bruhn's goals for returning to academia was to prepare an aircraft structural design text [4]. The first version of that comprehensive volume was completed in 1943, and with subsequent revisions in 1965 and 1973, remains in print, having sold over 100,000 copies, and continues to be a mainstay in industry.

WW II Developments

Since Purdue had taught aeronautical engineering for 20 years, and had greatly expanded coursework after the arrival of Professors Wood and Liston, Dean of Engineering A. A. Potter had decided by mid-1941 that aeronautical engineering should play a key role in Purdue's growing war training effort. Under his leadership, the School of Mechanical Engineering changed its name to the School of Mechanical and Aeronautical Engineering in 1942, and began a four-year B. S. curriculum in aeronautical engineering. This program required 160 2/3 credits, and students could also obtain a B.S. in mechanical engineering with an additional semester of work. An M.S. degree in aeronautical engineering was also offered at this time. The first students to pursue this "official" aeronautical engineering degree began study in 1940, and since the University went on an accelerated three-semester-per-year schedule during the war, received their diplomas in August of 1943.

Following the nation's formal entry in WW II after the Pearl Harbor attack of December 1941, Purdue pursued a number of aeronautical engineering efforts to support the war effort. The **Air Corps Cadet Aeronautical Engineering Program** was an extensive 12-week course given to groups of 50 students in January and in April of 1941. The rigorous curriculum was based on the fact that all students were engineering graduates with strong academic records. A large majority held mechanical engineering degrees, obtained from some 40-odd universities. These cadets were trained for Air Corps operations and aircraft maintenance. After completing the three-month Purdue program, they went to Chanute Field at Rantoul, Illinois, for several weeks of intensive practical training, and were then commissioned as Army Air Corps officers.

The **Curtiss-Wright Cadette Programs** resulted from a decision by the Curtiss-Wright Airplane Corporation to train young women for technical positions normally held by men at that time. Cornell, Iowa State, the University of Minnesota, the University of Texas, Rensselaer Polytechnic Institute, Pennsylvania State College, and Purdue participated in what became known as the Curtiss-Wright Cadette Training Program. The first 100 Cadettes who arrived at Purdue on February 12, 1943, were college graduates selected from throughout the country. Another group of 116 young women arrived on July 4, 1944. The first Cadette curriculum was common to all seven participating colleges, and consisted of two 22–week-long terms heavy in drafting, materials processing, and testing (Figure 9). The second program was shortened to six months with two twelve-week terms, and the age limit was lowered to 18 by the date of plant induction.

The U.S. Navy designed The Navy College Training program, usually referred to as the **Navy V-12 Program**, to solve its own critical staffing problems. The V-12 program began at Purdue on July 5, 1943, with 1263 men. Successive enrollments raised the total to 2730 at Purdue, with approximately 400 of these men receiving B.S. degrees. The V-12 program was conducted in 16-week terms, and by giving a semi-term in the fall of 1943, Purdue was able to provide a single calendar for both civilian and Navy students. Separate options were offered in the structures and the engines areas. The structures option required 12 credit hours of aerodynamics and 13 credits in aircraft structural theory, laboratory testing, materials and processes, structural design, and a course in vibrations and flutter. The engine option emphasized courses dealing with theory, testing, and design of aircraft power plants.

Post World War II Programs

At its spring 1945 meeting, the board of trustees approved an independent School of Aeronautics effective July 1, 1945, with Professor Elmer F. Bruhn as Acting Head. Professor Bruhn was widely known for his textbook on airplane structures. The broad title "School of Aeronautics" was selected because degrees were to be offered in both aeronautical engineering and air transportation.

Three new staff had joined the School of Mechanical and Aeronautical Engineering several months previously in anticipation of this official action. These new faculty included Mr. Grove Webster, who had been general manager of the Purdue Aeronautics Corporation, Dr. Paul Stanley, who had been director of the ground school for the Purdue Aeronautics Corporation, and Mr. Edward Cushman, who came from the Allison Company in Indianapolis. Mr. Webster joined the school with the rank of associate, and Dr. Stanley and Mr. Cushman as instructors.

The first tasks were to prepare detailed curricula for both the air transportation and aeronautical engineering programs, and to inform the public of Purdue's post-war aeronautical offerings. A pamphlet was published listing the air transportation and aeronautical engineering curricula. It described the relationship of the School of Aeronautics and the Purdue Aeronautics Corporation, as well as the various sections of the Aeronautical Engineering and Air Transportation departments. The proposed post-war curriculum in aeronautical engineering was primarily the thinking of Professors Bruhn and Liston, while the air transportation curriculum was due to Professors Bruhn, Webster and Stanley.

Air Transportation shared a common freshman year with other engineering curricula, followed by three options: airport management and operations, flight and flight operations, and traffic and administration. The airport management and operations option included aircraft maintenance and shop work to allow students to qualify for aircraft and engine mechanic's certificates. The flight and flight operations option provided all ground and flight courses needed for a professional pilot's rating.

The goal of the post-war Aeronautical Engineering program was to provide a well-grounded understanding of how a flight vehicle is designed to meet given performance and operating requirements. The common freshman-engineering curriculum was followed by a summer session devoted to shop work, descriptive geometry, and drafting. The next one and a half years consisted of courses in mathematics, physics, engineering mechanics, drafting, economics, and thermodynamics. The second half of the junior year required engineering mechanics, aerodynamics, thermodynamics, materials testing and mechanisms. The final year allowed the choice of one of four options: airplane design, aircraft power plants, airline engineering, or production management.

There were only two professors and two instructors available in 1945, so a hiring effort began immediately, and by 1949 there were ten professors and four instructors on the faculty. The post war surge of students produced rapidly increasing enrollment, and by Fall of 1947 there were about 700 students enrolled in the two degree programs. By that time a new building had been constructed at the university airport, located adjacent to campus, to provide additional space beyond the two original campus buildings.

Graduate education in the School of Aeronautics began with a Master's Degree program in Aeronautical Engineering in 1946. Ph. D study was approved for aerodynamics and propulsion in 1948, followed by the structures area in the early 1950's. The new school's first Ph.D. was awarded to R. L. Duncan in 1950 for his work with Professor M. T. Zucrow on the performance of gas turbines. A Master's Degree program in Air Transportation came into existence after 1950.

The 50's Decade

Professor Bruhn decided to return to full-time teaching in 1950, and Milton U. Clauser (Figure 10) was selected to be the next School Head. Dr. Clauser came from the Douglas Aircraft Corporation in El Segundo, California, where he had been head of mechanical design. During the early 1950's, the School enrollment began to drop as the WW II veterans graduated, alleviating some of the pressure felt during the immediate post war years.

The aircraft internal combustion engine laboratory was well established and being used by undergraduate and graduate students (Figure 7). This laboratory was developed during the 1940's by Professor Joseph Liston, and consisted of two test cells where students could run engineering tests of reciprocating-type aircraft engines. By 1950 one of the test cells had been modified to use a small Westinghouse axial flow turbojet engine. The jet propulsion area was developed under Maurice J. Zucrow's leadership, but most of that program moved to Mechanical Engineering in 1953, leaving only a small part in Aeronautical Engineering.

At this time the aerodynamics laboratory had five wind tunnels in operation. The latest of these was a large subsonic tunnel with a capability of 350-400 miles per hour (Figure 10) designed by Professor G. M. Palmer, and built mainly of plywood with student help. The test section was approximately 11.5 square feet, and it used a 400 H.P. electric motor. This tunnel was upgraded by means of a large grant from The Boeing Company in the early 1990's and is still in use. Other tunnels in use at that time included a Japanese variable-density wind tunnel that had been confiscated and brought to this country after the war. Its use was rather limited because of its low power (100 H.P.). It had a 15-inch throat and was capable of speeds up to 300 mph. Another 110-mph tunnel that was originally powered by a Dodge auto engine, was modified and lengthened by Professor Palmer and driven by a 50 H.P. electric motor. This tunnel was used primarily in the required wind tunnel courses for aero students. Two other small wind tunnels, including a smoke tunnel, were moved from campus to the airport facility in 1948. A water table was added in 1953 for demonstrating compressible and viscous flow. At about the same time a shock tube was added for study and research in high-speed flow.

The structures laboratory consisted primarily of load-applying equipment and instrumentation involved in measuring the effect of various loads on flight vehicles (Figure 11). The following equipment were used: a 60,000-lb. Tinius Olsen testing machine, a 60,000-lb. Tate Emery testing machine, a Rockwell hardness tester, several tension dynamometers, strain indicators, load cells, oscilloscopes, vibration meters, vibration analyzers and velocity pick-ups.

The Aeronautical Engineering program was modified in 1954 to include a theoretical option for students desiring a stronger background in mathematics and physics. Also, because of the loss of some of the propulsion capability, the previous airplane design and power plant options were combined to form the airplane and power plant option. About this time, Professor Clauser left the university, and Dr. Harold De Groff became the new Head.

By the mid 1950's, the Air Transportation enrollment was dwindling, so a decision was made to close this program effective with the 1958 graduating class. Some aspects of this field were transferred, however, to a new Transportation Studies program in the Department of Industrial Management. The School's name was then changed to the School of Aeronautical Engineering in July 1956.

With space flight coming closer to reality, the School began to initiate new courses that reflected that interest. In the fall of 1957, Angelo Miele offered a course entitled "A preliminary approach to the mechanics of terrestrial and extraterrestrial flight." By the following year, Hsu Lo offered a course on orbit mechanics. This was followed by a course on astrophysics given by Paul Lykoudis. Research in these areas included work on chemical and radiative aerodynamics, plasma jets and high temperature materials and structures.

A New Era

In 1960, the School of Aeronautical Engineering and the Division of Engineering Sciences were merged, and the School name changed to include both of these areas. The Engineering Sciences department had a small building on the main campus, so in 1960 most of the faculty from both programs were housed in that building, but the laboratory buildings at the airport were still retained. The Division of Engineering Sciences had been created in 1954 to offer advanced engineering mechanics with a strong basis in mathematics and physics. Since the Aeronautical program had been moving in that direction, it was felt that the two curricula could function well together. The expectation was that they would find common ground and merge into a single program. Although there was cooperation in developing basis courses at the sophomore level, the faculty could not agree to a single unifying curriculum that satisfied all aspects of the School's mission. Thus, two separate degrees were maintained until the Engineering Sciences program was terminated in 1973.

During the early years of this era, Professor De Groff became involved with a small company in the Research Park, and took a two-year leave of absence to devote more time to that project. Professor Paul Stanley became the acting Head during that time period. De Groff later came back to the Dean of Engineering Office, and the School had a series of acting heads until Hsu Lo was named the Head in November of 1967. John Bogdanoff was Head from 1971 to 1972.

A new type of graduate program was established in June 1963. Titled Master of Science in Astronautics, this new degree was developed in conjunction with the U.S. Air Force Academy. A select group of 12 to 15 cadets who had advanced credit beyond that necessary for graduation were brought to the Purdue campus immediately after graduation from the Academy. They took three courses during the summer session, followed by a special one-month course in August, and then 15 credit hours during the fall semester with graduation in January. The original program involved a thesis, but that was soon deleted in favor of additional courses due to time constraints. After a few years, the program was lengthened to include the entire academic year, and provided courses in hypersonics, electronics, propulsion, along with choices in a major and minor area. This program lasted about twelve years and was highly successful in that it enabled Air Force personnel to acquire a Master's degree relatively quickly before going on to flight training. Although not intended to be an astronaut-training program, seven graduates subsequently did become astronauts. In addition, Purdue students from a variety of other disciplines have also been selected for space flight over the years, and there are now twenty-two Purdue graduates who have been astronauts. The university was greatly saddened in January of 1967 to learn that an Apollo spacecraft fire on the ground had killed two Purdue graduates, Gus Grissom and Roger Chaffee. Grissom had been involved in other space flights, but this was to be Chaffee's first. Two campus buildings were named in their honor. Grissom Hall was remodeled in 1967, and became the primary home for Aeronautical Engineering and for Industrial Engineering.

The School also began to participate in the Engineering Co-op program in 1964. This course allowed five work sessions alternating with study semesters beginning after the freshman year. The program took five years to complete and included all summer sessions during that time. This co-op effort is still quite active, and provides an excellent method of coordinating industrial experience with academic training.

During this time period, several new laboratories were created to complement existing ones. An IBM 1620 digital computer was acquired, and all students had to learn programming. Other laboratories provided test facilities in experimental engineering sciences, magneto-fluid mechanics, material research, random environments and composite materials.

Transition and Growth

As the Engineering Sciences program was phasing out, the School was renamed the School of Aeronautics and Astronautics, the title retained to the present time. Professor Bruce A. Reese was appointed the new school Head in 1973, transferring from the School of Mechanical Engineering. This was the first step in bringing a stronger propulsion influence back to the aero curriculum.

The early 1970's were a time of reduced student enrollment due to a downturn in the aerospace industry. This came about because of a mid-east oil embargo, which caused increased oil prices, produced a reduction in air travel and a reduction in new commercial airplane orders. Military spending also decreased, and the end of the Apollo missions curtailed spending in the space field. Curriculum changes made programs more flexible to attract students, and to facilitate a continuation directly to a Master's degree. Basic courses were required in aerodynamics, structures, thermodynamics, airplane performance, and control systems. The student could then choose a major and a minor area and also have 12 credit hours for technical electives over a wide range of courses. The major and minor areas were: (1) aerodynamics, (2) flight mechanics, astronautics, guidance and control, (3) propulsion, and (4) structures and materials. There were also a few courses in air transportation that had been developed recently by a new faculty member. Graduate education had been growing continuously for several years, particularly in control systems and in space mechanics, and was accompanied by a steady rise in sponsored research from various government agencies and private industry. The 1970 to 1980 decade saw sponsored research grow from $350,000 to $500,000 per year. Faculty members diversified their research interests to include wind tunnel testing of buildings, automobiles, and ships. Research was also done in bio-engineering, aerodynamic noise, composite materials, and seismic resistance of fossil-fuel power plants.

After a low undergraduate enrollment of about 200 students (excluding freshmen) in 1972, the enrollment began to steadily increase throughout the decade, reaching 500 in 1980, and increasing to 570 students by 1989. Graduate enrollment followed a somewhat similar pattern, but the changes were not as drastic, since as industrial jobs became more difficult to find, more students did graduate work.

Professor Henry Yang became the new School Head in 1980. He had come to Purdue in 1968 and was very active in research in finite element analysis. Under his leadership the School grew in student numbers and in research expenditures, so that by 1985, the sponsored research budget had reached $1,500,000 per year. The structure of the undergraduate curriculum remained the same, but a number of new courses were introduced which broadened the range of interests. Some of these new courses were: fatigue of structures and materials, flight dynamics laboratory, unsteady aerodynamics, digital flight control, transonic aerodynamics, nonlinear systems, advanced composite materials, optimal trajectories, low gravity fluid mechanics, and optimal systems design. During this time period, aerospace design received increased emphasis by means of a program supported by Lockheed Missiles and Space Company at the senior level, and another design course at the sophomore level. Design projects were developed with Lockheed engineers, who visited the campus twice a semester to evaluate the student's work. Those engineers assisted with the final design evaluation at the end of the semester, and awarded prize money to cover expenses of preparing reports. Airplane design was also helped by means of funding from the University Space Research Association (USRA) and later from the Thiokol Corporation.

In 1984, Professor Yang became the Dean of Engineering at Purdue, and held that position for ten years before becoming Chancellor at the University of the University of California at Santa Barbara. His successor as School Head was Alten "Skip" Grandt who joined the faculty in 1979 in the structures and materials area. By 1990, the undergraduate enrollment had reached a maximum and was decreasing rapidly. The graduate enrollment did not show such a significant change, and sponsored research spending continued to increase, reaching a yearly value of $2,300,000 in 1993. The undergraduate curriculum remained relatively unchanged in the late 1980's and 1990's, although a number of new courses were developed to represent the faculty interests. New laboratory developments during this period included a laser laboratory, a guidance and control laboratory, a composite materials laboratory, and rocket combustion and propulsion laboratory. In 1993, John P. Sullivan became the School Head, and Thomas N. Farris replaced him in 1998.

Current Status of the School

As of the Fall semester of 2002, the School of Aeronautics and Astronautics had 22 faculty, 407 undergraduate students (excluding freshmen), and 157 graduate students (90 M.S. and 67 Ph.D.). The separate Department of Aviation Technology numbered 33 faculty and 610 undergraduate students. For comparison, the Purdue Schools of Engineering enrollment is approximately 8000 students with 275 faculty, and the total Purdue West Lafayette campus enrollment is approximately 38,000.

Current Purdue President Martin C. Jischke is formally a member of the Aeronautics and Astronautics faculty. Other faculty play research leadership roles in many technical disciplines as evidenced by current external research expenditures of more than $4 million annually. Many faculty serve on prestigious editorial boards, 7 are fellows of at least one major society (AIAA, AAS, ASME, SEM), an additional 6 are associate fellows of the AIAA, and one emeritus professor is a member of the National Academy of Engineering.

The present Aeronautics and Astronautics undergraduate curriculum has two areas of concentration, aeronautics, and astronautics. These two curricula contain many of the same basis courses, but differ in terms of required courses in areas such as dynamics and control, and propulsion. The astronautics curriculum contains rocket propulsion, spacecraft attitude dynamics, and spacecraft design, while the aeronautics curriculum contains jet propulsion, flight dynamics and control, and aircraft design. Both curricula require 15 credit hours of major and minor area electives that may be chosen to emphasize a student's particular interest.

The School is involved in research in all disciplines. Aerodynamics research includes computational methods, separated flows on bodies at high angles of attack, aerodynamics of rotors and propellers, boundary layers, wakes, and jets in V/STOL applications and noise, experimental methods using laser systems, and boundary layer transition. Laboratory equipment includes the Boeing subsonic wind tunnel with a 4x6 ft. test-section, along with three smaller wind tunnels and a water table. The Boeing Compressible flow Laboratory includes a 2-inch blow-down wind tunnel, and a shock tube. Also in use are a 4 inch Mach 4 Ludweig tube, and a 9.5 inch Mach 6 Ludweig tube with a quiet flow test section.

The Control Systems Laboratory includes high-end work stations to develop methods and software for the analysis and design of complex dynamical systems. Undergraduate laboratories include a two-degree-of-freedom helicopter experiment, and a three-degree-of-freedom experiment to simulate the attitude dynamics of a flexible spacecraft. A remotely piloted vehicle is under development to perform a variety of dynamics and control experiments.

The propulsion area has an Advanced Propellants and Combustion Laboratory composed of two reinforced concrete test cells. One cell contains a rocket thrust stand handling thrusts to 1000 lbf. The other cell is for hybrid rocket combustion studies for a variety of nontoxic hypergolic propellants. The newly renovated High Pressure Laboratory in the Zucrow Laboratory is shared with Mechanical Engineering. This facility has two test cells for testing propulsion devices to 10,000 lbf thrust. One cell is devoted to air-breathing propulsion, and one to rocket propulsion. The Energy Conversion Laboratory located at the Aerospace Sciences Laboratory has four work areas: propellant area, electrochemistry area, physical energy conversion area, and the catalysis area.

Structures and Materials research includes work in composite materials, computational structural mechanics, damage tolerance analysis, experimental structural analysis, aeroelasticity, tribology, manufacturing, wave propagation, and optimal design methods. The McDonnell Douglas Composite Materials Laboratory contains equipment for fabrication and testing of composite laminates. The laboratory includes an autoclave, a hot press, an En Tec filament-winding machine, a water jet cutting machine, an x-ray and an ultrasonic C-scan system. The Fatigue and Fracture Laboratory is equipped for research directed at evaluating the damage tolerant properties of materials and components. Two computer controlled electro-hydraulic test machines and associated equipment are used to measure fracture loads, and to study fatigue crack formation and propagation. The Structural Dynamics Laboratory has the latest equipment for recording ultra-dynamic events, such as Norland and Nicolet recorders, a one-million-frame-per-second camera, an impact gun, and data acquisition equipment for the study of impact to structures and stress waves. The Tribology and Materials Processing Laboratory is maintained jointly with the Center for Materials Processing and Tribology. A test machine is available for the study of fretting fatigue at room and elevated temperatures, a frictional apparatus for high and low speed sliding indentation, lapping and polishing equipment, a vibration isolation table, and a variety of equipment for measurements. A piezo-electric based load frame is available to perform high frequency fretting fatigue experiments related to HCF of aircraft engines.

Alumni Accomplishments

An outstanding academic program needs quality students to succeed. As Indiana's only state supported engineering program, Purdue has an obligation to admit qualified state residents, but also attracts a number of out-of-state students, so that undergraduate enrollment is more than 50% out-of-state. Few other disciplines enjoy a student body with such an avid interest in their profession. Indeed, the aerospace mystique has a powerful motivational influence for learning, and plays a most effective role in outreach activities directed toward encouraging educationally disadvantaged students to higher levels of achievement. Thus, aerospace engineering students tend to be among the most capable and enthusiastic students on campus.

Alumni achievements are the standard by which any academic program is ultimately judged, and in this regard Purdue is widely recognized. The School inaugurated the "Outstanding Aerospace Engineer" designation in 1999 by recognizing its 58 alumni who had previously been awarded an Honorary Doctorate, a Distinguished Engineering Alumni Award, or who had served as a NASA astronaut. Twenty-one additional alumni have been selected for this honor as of December 2002. These alumni have demonstrated exemplary service to industry, government, academia, or other endeavors that reflect the value of an aerospace engineering degree.

Perhaps the most well known alumni are those who have become astronauts and have participated in space flights, which include Mercury, Gemini, Apollo, space shuttle, Mir space station, and the International Space Station. These individuals are listed below.

Purdue Astronauts (Aeronautics and Astronautics)

Neil A. Armstrong, John E. Blaha, Roy D. Bridges, Mark N. Brown, John H. Casper, Roger B. Chaffee, Richard O. Covey, Guy S. Gardner, Gregory J. Harbaugh, Gary E. Payton, Mark L. Polansky, Loren J. Shriver, Janice Voss, Charles D. Walker

Purdue Astronuats, (Other disciplines)

Eugene A. Cernan, Andrew J. Feustel, Virgil I. Grissom, Michael J. McCulley, Jerry L. Ross, Mary E. Weber, Donald E. Williams, David A. Wolf

Some specific space flight accomplishments from these Purdue alumni are summarized below.

- As of November 2002, 52 of 143 (36.4%) total US manned flights have had at least one Purdue alumnus as a crewmember (5 flights had crews with 2 Purdue alumni).
- Two of the seven longest US space flights (aboard Russian space station MIR) were by Purdue alumni (John Blaha and David Wolf)
- Purdue alumni were the first (Neil Armstrong) and last (Gene Cernan) humans to step on the moon.
- In April of 2002, Purdue alumnus Jerry Ross became the first human to be launched into space 7 times. Ross also has the most US space walks (9) and longest accumulated US space walk time (58 hours 18 minutes).
- By the end of 2002, Purdue alumni have flown 610 days in space, believed to be the longest total accumulated by alumni from any US university.

Summary

The goal of this paper is to summarize the history of aerospace activity at Purdue University. This is a many-faceted story (see Reference 5 for further details), as Purdue has grown to world prominence and leadership in aerospace education and research. Although the School of Aeronautics and Astronautics was not formally established as a separate academic unit until July 1, 1945, aeronautical education and research at Purdue began much earlier. The Purdue Aero Club was organized on campus in 1910, and was instrumental in bringing the first aircraft to the Lafayette community in 1911. Aeronautical engineering courses were first offered by the School of Mechanical Engineering in 1921, and extensive World War II programs led to the first aeronautical engineering degrees awarded by the School of Mechanical and Aeronautical Engineering in August of 1943. Through December of 2002, Purdue University has produced 6,011 B. S. degrees, 1,331 M. S. degrees, and 444 Ph.D.'s in aerospace engineering. These alumni have made many significant contributions to aerospace engineering and other technical and non-technical fields.

As the School marks the end of the first century of manned flight, it looks forward to strengthening its leadership in the aerospace arena. It has a dynamic faculty involved with a broad spectrum of basic research issues of national importance. This faculty is backed by an excellent support staff and well-equipped, modern laboratories and computational facilities. The School enjoys an enthusiastic and talented student body that is tremendously excited by the opportunity to further advance aerospace technology. Most of all, the School has a tradition of excellence and accomplishment earned by prior generations of faculty and alumni that encourages the current members to higher levels of achievement.

Purdue University relishes the continued challenge to provide students with the aerospace technology needed for the second century of manned flight. Indeed, it looks forward to helping government and industry shape the future aerospace opportunities for our nation and the world. Purdue faces the next hundred years of flight with confidence and optimism. It is proud of its accomplishments, delights in those of its alumni, and looks forward to continuing to play a leading role in providing the world with undreamed-of opportunities for air and space travel.

References

1. H. B. Knoll, *The Story of Purdue Engineering*, Purdue University Studies, 1963.
2. R. Kriebel, "Old Lafayette," newspaper columns of July 15 and October 7, 1990, *Journal and Courier*, Lafayette, Indiana.
3. K. D. Wood, *Airplane Design, A Textbook on Airplane Layout and Stress Analysis Calculations with Particular Emphasis on Economics of Design*, published by the author, 1st edition, 1934.
4. E. F. Bruhn, *Analysis and Design of Aircraft Structures*, 1st edition, 1941. Subsequent revisions titled *Analysis & Design of Flight Vehicle Structures*, Tri-State Offset Company, 1965, revised 1973.
5. A. F. Grandt, Jr., W. A. Gustafson, and L. T. Cargnino, *One Small Step: The History of Aerospace Engineering at Purdue University*, School of Aeronautics and Astronautics, Purdue University, 1995 (392 pages).

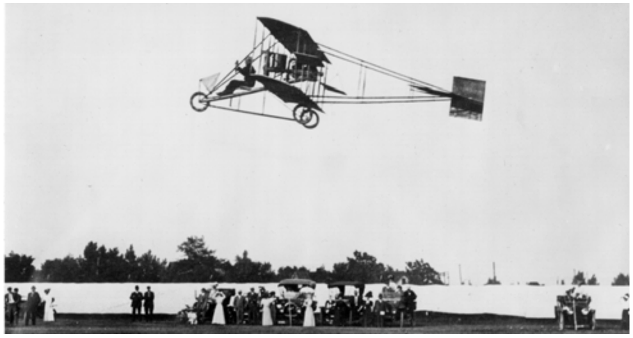

Figure 1 Greater Lafayette's first aviation show, co-sponsored by Purdue University and held June 13, 1911 on the Purdue campus.

Figure 2 Airplane on Purdue campus, 1918.

Figure 3 Aeronautics laboratory with wind tunnel, Curtiss Robin aircraft, and engine, May 1930.

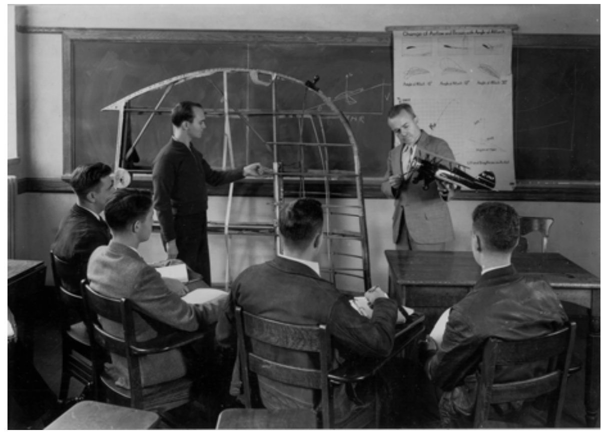

Figure 4 Professor George Haskins (standing right) with aeronautical engineering class, September 1934.

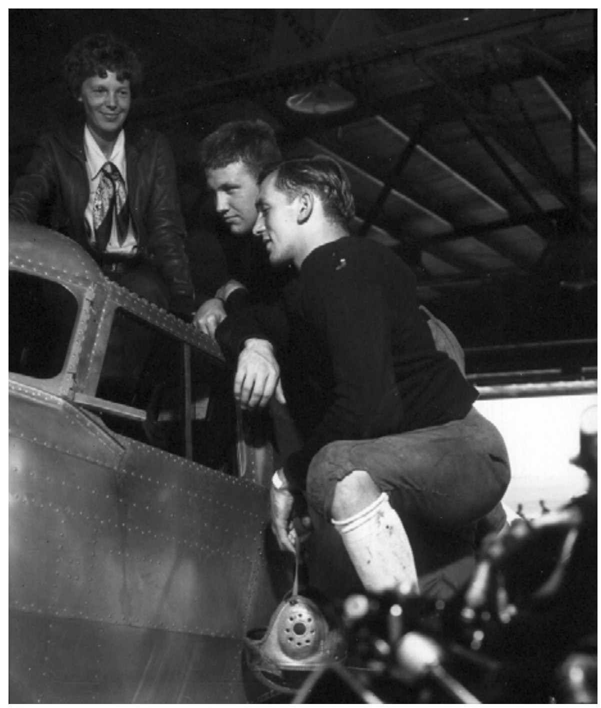

Figure 5 Amelia Earhart, "Counselor on Careers for Women" at Purdue from 1935-37 with students, September 1936.

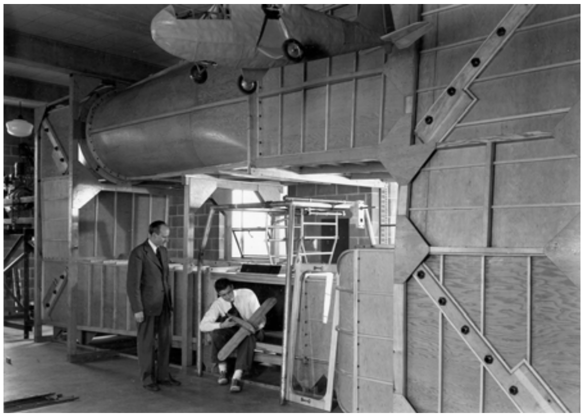

Figure 6 Professor K. D. Wood with student and wind tunnel, February 1943.

Figure 7 Professor J. Liston (second from left) and students examining aircraft engines, circa 1943.

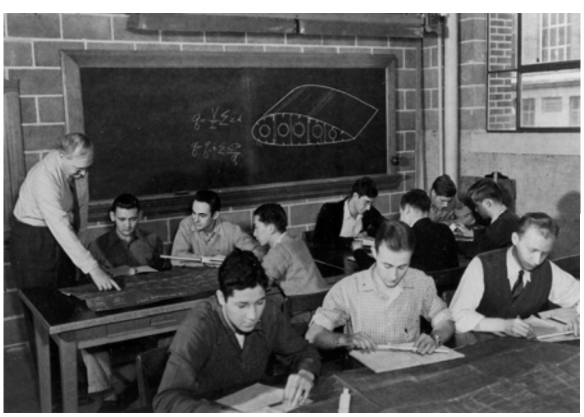

Figure 8 Professor E. F. Bruhn and structural analysis class, 1942. Note slide rules and shear flow formula on black board.

Figure 9 Curtiss-Wright Cadetts in structures laboratory, 1944.

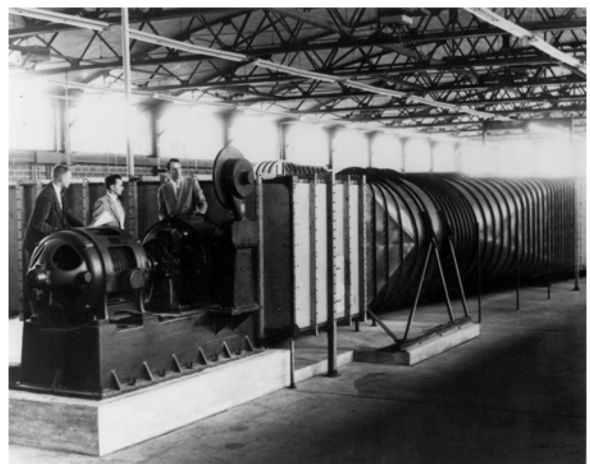

Figure 10 Large subsonic wind tunnel constructed under direction of Professor Palmer (center), 1951. Tunnel was renovated and renamed the Boeing Wind Tunnel in 1992. Also shown are Professors DeGroff (left) and Clauser (right)

Figure 11 Structures laboratory, circa 1945.