AN EDUCATIONAL INSTITUTION IN TRANSITION

Its Predecessors, People and Progressive Programs

Introduction: Whenever people on the Virginia Peninsula hear the word 'apprentice', they often associate it with the apprentice program at Newport News Shipbuilding (NNS). But a similar program, located just a few miles away, also deserves recognition and acknowledgement of its many successes.

The Langley Research Center (LaRC) dates back almost a century. Initially named the Langley Memorial Aeronautical Laboratory (LMAL), it was the first research facility created by the National Advisory Committee for Aeronautics (NACA) before that organization was absorbed by the National Aeronautics and Space Administration (NASA).

The first NACA apprentice school, created at Langley in 1941, initially mirrored industrial programs of that era. Over time, the work/study techniques employed there have required the introduction of an ever-growing sophistication in technical curriculums to support a variety of missions that are quite often literally out of this world. Currently, another educational transition to support the nation's aerospace and environmental programs in the 21st century is underway at LaRC.

Graduates of this apprentice program have profited greatly from their training, and they have contributed much to the day-to-day achievements of this famous and highly successful aerospace organization. Numerous LaRC apprentice graduates have attained responsible management positions and have been...and are...innovators and leaders in important NASA technological developments.

Following is a brief narrative of what is currently called the Langley Engineering Technical Apprentice Program, prefaced by a 'time line' of aviation history that includes key events pertinent to the Langley Research Center as well as its apprentice school. A synopsis of NACA's early days is also presented, along with interspersed recollections of several graduate apprentices.

Bill Lee

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Key Events Pertinent to Langley Research Center's Apprentice Program in American Aerospace History

**1903** Wright Brothers' successful heavier-than-air flights at Kitty Hawk, NC

**1914** World War I began in Europe

**1915** The National Advisory Committee for Aeronautics (NACA) established

**1917** America entered World War I

**1917** Langley Memorial Aeronautical Laboratory (LMAL) and the adjacent US Army Air Service's Langley Field established

**1919** Construction of first rudimentary wind tunnel completed at LMAL

**1920** For next two decades, LMAL technicians informally trained 'on the job'

**1922** World's first variable density wind tunnel became operational at LMAL

**1927** Charles Lindbergh's solo, non-stop flight across the Atlantic

**1931** Full scale wind tunnel completed and placed in operation at LMAL

**1938** Total number of Langley laboratory employees: 426

**1940** LMAL senior management recognition of need for an apprentice program

**1941** America entered World War II

**1941** A four-year apprentice program established at NACA Langley

**1942** Given credit for prior work, apprentices studied at night without pay

**1942** Fourteen apprentices became the first graduating class at LMAL

**1945** NACA Langley employment peaked at 3,000; World War II ended

**1947** Apprentices & their instructors paid for class work during normal work hours

**1948** Name changed to Langley Aeronautical Laboratory (LAL) [also known as NACA Langley after other NACA facilities were created in the early 1940s]

**1951** Apprentice Alumni Association established at NACA Langley

**1953** Class rings first made available to graduating apprentices
1957 World’s first satellite launched into space

1958 NACA became the National Aeronautics and Space Administration (NASA); LAL renamed Langley Research Center (LaRC) [aka NASA Langley]

1961 Manned Spacecraft Center established near Houston, Texas

1965 First black student admitted to NASA Langley's apprentice program

1966 Biggest graduating class in history of LaRC apprentice program...87

1969 First manned lunar landing

1971 Co-op program established with Thomas Nelson Community College

1976 First year since 1942 in which no new apprentices were admitted

1977 Two female apprentices completed their training at NASA Langley

1980 All individuals accepted into LaRC apprentice program had some prior college; given 18 months credit towards apprenticeship completion

1984 The National Transonic Facility (NTF), the world’s largest pressurized cryogenic wind tunnel became operational at NASA Langley

1988 Langley Research Center began reimbursing tuition for co-op students

1988 The apprentice program at LaRC expanded to six years

1990 Langley Research Center’s system of apprenticeship revamped and program renamed the Engineering Technician Apprentice School

1991 Graduating class of 34 reflects significant social changes and the majority of the graduates earned Associate of Science degrees via co-op program

1999 Apprentice program at Langley Research Center terminated due to severe cutbacks in funding

2007 LaRC’s apprentice program reinstated; fourteen students enrolled

2011 Federal Budget Control Act constrained activities at NASA Langley

2014 Meeting rigorous scholastic and work-related requirements over a period of seven years, nine apprentices received certificates of program completion

2014 Langley’s Engineering Technician Apprentice Program being revamped to support 21st century aerospace and environmental missions at LaRC
**Before the Beginning:** In 1915, just a dozen years after the Wright brothers first flew, the National Advisory Committee for Aeronautics was created. By that year, America was lagging far behind European countries in aviation development. Still, it took a 'rider' to the 1915 US Navy appropriation bill to create NACA; a classic...if not admirable...example of American political compromise.

The Advisory Committee, composed of twelve volunteers from industry and government, was given a bold marching order:

"To supervise and direct the scientific study of the problems of flight, with a view to their practical solutions"

For this ambitious purpose, the committee was allotted just $5,000...which was earmarked for travel and other expenses. The committee members were unpaid and were not provided with any facilities for actually doing anything to advance the cause of aviation, despite the obvious need for a research laboratory.

Due to the impetus of World War I, NACA's budget was increased significantly and the organization's first laboratory was established in 1917 adjacent to the newly created US Army Air Service's Langley Field in Elizabeth City Country, Virginia [present-day City of Hampton].

The scientific research facility, like the Army Air Service’s air base, was named for American aviation pioneer, Samuel Pierpont Langley [left]. To help differentiate the civilian organization from the military, NACA’s first physical installation was initially named Langley Memorial Aeronautical Laboratory (LMAL).

One of its first projects was to build a five foot [diameter] wind tunnel [right] for limited testing of model aircraft. Finished in 1919, it could not be used for over a year because the fledgling facility did not have sufficient electrical power to operate it. When the first aeronautical experiments were conducted using this device, LMAL had a grand total of four researchers and eleven technicians on its payroll.
In 1921, LMAL contracted with Newport News Shipbuilding (NNS) to build a pressure vessel to house a wind tunnel that could be operated at variable densities [depicted on the left during early use]. In subsequent years, additional and much larger wind tunnel components were created at NNS, then match-marked and moved in huge sub-assemblies to the Langley facility for erection.

During the 1920s and the 1930s, NNS made additional 'contributions' to the work at LMAL; albeit involuntarily. During those decades, NACA's facility at Langley Field experienced a growing need for accomplished machinists, toolmakers and other craftsmen. With no organized apprentice training program of its own before World War II, LMAL offered NNS employees, especially apprentice graduates, opportunities in the exciting, stimulating and expanding field of aviation, plus higher pay and job security under the Federal Civil Service Program.

One of the NNS Apprentice School alumni who made that move was Warren Long. He completed his time in the shipyard's machine shop in 1899. After a quarter of a century of working at NNS, he obtained employment at LMAL in 1925, where he practiced his trade in Langley's machine shop until 1953.

**Early, Informal Training at LMAL:** The Langley facility, like the majority of industrial and technically-oriented organizations in the United States, initially followed the time-honored practice of unstructured 'over the shoulder' training for its incoming employees. But the sophistication and technical complexity of the work at LMAL also resulted in hiring a large number of engineering graduates.

Some of the engineers who took positions at LMAL were from 'up north'. They frequently found the ways of the south too slow. Brilliant, but often not very diplomatic...much less practical in everyday activities...they did not endear themselves to the local citizenry, who often derisively called them 'Nacka-nuts'.

One of LMAL's important missions in the beginning was to build and test scale model airplanes. This unique activity attracted a number of youthful model-building enthusiasts; many of whom were of high-school age. Most of them, as well as many of the engineers who...in their own youth...had been captivated by flight, spent much of their after hours' time building and flying model airplanes.

What they learned through experience in the rural fields of Elizabeth City County often found useful application in their 'day jobs'. As a result, administration officials at LMAL gave preference to applicants who had modeling 'in their blood'.
The Full-Scale Tunnel: A good example of the growing capability of LMAL and a corresponding need for well-trained technicians came about in 1931. Nick-named 'Cave of the Winds', this huge facility, once placed in operation ran for 80 years.

In the 1930s, it was state-of-the-art, capable of testing most full-sized aircraft of that era. LMAL employees designed and manufactured ingenious points of attachment to support aircraft without interfering with test results.

Langley Memorial Aeronautical Laboratory hosted a series of aircraft engineering conferences between 1926 and 1939. Using the Full-Scale Tunnel with a P-26A 'peashooter' pursuit airplane on the test stand as a 'showcase backdrop', the following group picture was created at the 1934 event. Included in that august group were Orville Wright, Charles Lindbergh and Howard Hughes, and other famous figures in American aviation history.

It may look and sound glamorous...but it wasn't. Engineers worked long hours. Recently hired LMAL employees laboriously plotted reams of data that had to collected by reading instruments and then recorded by hand. Technicians made sure high value test vehicles in the form of full-size aircraft were securely mounted. These technicians also installed instrumentation, operated data acquisition systems, made modifications to the test article and monitored every test for the slightest abnormality.
One individual who worked as a machinist at the Full-Scale Tunnel's fabrication annex was a former NNS apprentice named Joe Walker. Walker finished his time at the shipyard as a machinist in 1917 and went to work at LMAL in 1928. After World War II ended, he became the chief of mechanics at the Full-Scale Tunnel complex until he retired in 1966.

Joe Walker's sense of humor is reflected by the following tale that involved Henry Reid, LMAL Director during World War II. On V-J Day, a crowd of employees was celebrating in the street next to the Full-Scale Tunnel. Henry Reid left his nearby office and joined the crowd. Joe Walker pulled out a flask of whiskey, and asked Henry Reid if he wanted a celebratory drink. Reid accepted, took a long pull off the flask and gave it back to Walker, who promptly put it back in his pocket.

Reid asked: "Joe, aren't you going to have a drink?". Walker replied: "Hell no, you can get fired for drinking on the job!"

**World War II Demands:** LMAL had 426 employees in 1938. NACA's total budget was a little over $4 million that year. By the end of the war, these numbers had expanded exponentially. Two more labs were created [NACA Ames and NACA Lewis]. As a result, LMAL was often referred to as NACA Langley...for a few years. NACA's employment peaked in 1945 at 6,077 [3,000 alone at LMAL]. The organization's total budget that year was almost $41 million.

Once America was at war, LMAL launched a vigorous recruitment campaign, competing with NNS for local talent. Auto mechanics left garages to work on aircraft engines. Blacksmiths applied their metal forming skills to produce smooth, streamlined metal surfaces for warplanes. Maintenance workers from North Carolina textile mills were found to be excellent wind-tunnel mechanics.

In addition, LMAL hired school boys to work as shop assistants, messengers and model makers. Local school teachers, mostly female, spent their summers at Langley as human computers, and as technical report writers and editors. Other women, for the first time, worked in the fabrication shops at NACA Langley.

Some officials at the Langley facility recognized, even before World War II begun, that the rapid and far-ranging expansion of research work ongoing there required a more formalized approach to educate the technicians needed to support the facility's scientists and engineers. One of those officials was Percy Crain, a Georgia Tech graduate who had joined the staff at LMAL in 1939. Another was an associate, William Mayo. He was a 1934 NNS apprentice graduate who had migrated to LMAL in the depression-plagued 1930s.
From Concept to Reality in a Year: One evening in late 1940, a group of Langley Memorial Aeronautical Laboratory's key people and some officials from NACA's headquarters in Washington, DC gathered socially. As so often happens, when intense and driven people meet on such occasions, the conversation inevitably turned to business. Thirty years later, William Mayo recalled:

"Somehow we got on the subject of training for the years ahead. I made an impromptu speech on why Langley should have an apprentice school."

Those in attendance that night knew what he knew; that LMAL was hiring scores of new employees but doing very little training regarding the specialized needs of the Langley facility. They agreed that their organization should start bringing in young men, better educate them, provide them with applicable skills and at the same time have them work daily with the professionals they would later support. The benefit to NACA, after four years, would be a cadre of skilled craftsmen who also understood the language of the aeronautical engineering professionals.

Apparently, Percy Crain took on the task of recommending and getting approval for the creation of just such a program. And, as so often happens, he was then asked to turn that concept into reality...which he did...thus earning himself the unofficial title of father of NACA Langley's apprentice program.

It is not known exactly when Percy Crain found it necessary to bow out of the apprentice program development to give his full attention to demanding engineering work associated with the war effort. Charles A. Hulcher, a supervisor in the LMAL Personnel Department, became the program's first Apprentice Administrator. He was assisted by Frank Penland, a LMAL personnel supervisor.

In December of 1941, the fourteen employees identified below were selected to become NACA Langley's first class of apprentices in the trades indicated.

<table>
<thead>
<tr>
<th>Name</th>
<th>Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>John H. Breisch</td>
<td>Machinist</td>
</tr>
<tr>
<td>Clarence T. Brown, Jr.</td>
<td>Aircraft Sheetmetalsmith</td>
</tr>
<tr>
<td>Charles W. Cardwell</td>
<td>Aircraft Sheetmetalsmith</td>
</tr>
<tr>
<td>Charles M. Chambers</td>
<td>Machinist</td>
</tr>
<tr>
<td>Durwood A. Dereng</td>
<td>Aircraft Modelmaker</td>
</tr>
<tr>
<td>Raymond M. Hulcher</td>
<td>Instrument Maker</td>
</tr>
<tr>
<td>Caldwell G. Johnson, Jr.</td>
<td>Mechanical Draftsman</td>
</tr>
<tr>
<td>Robert E. Little</td>
<td>Aircraft Sheetmetalsmith</td>
</tr>
<tr>
<td>Dale B. Lively</td>
<td>Aircraft Modelmaker</td>
</tr>
<tr>
<td>John P. Morgan</td>
<td>Aircraft Modelmaker</td>
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<tr>
<td>Norman R. Richardson</td>
<td>Aircraft Modelmaker</td>
</tr>
<tr>
<td>Roland Tully</td>
<td>Machinist</td>
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<tr>
<td>Ralph L. Westphal</td>
<td>Wind-Tunnel Mechanic</td>
</tr>
<tr>
<td>Francis S. Wolak</td>
<td>Aircraft Modelmaker</td>
</tr>
</tbody>
</table>

All of them already had at least two years of hands-on shop experience. A few had some college education, but had elected to forgo a career in engineering to work with their hands at NACA Langley. Collectively, they represented a pretty representative cross-section of the technical skills needed at LMAL.
**NACA Apprentice Class #1:** These young men, once they were formally designated as apprentices, were given credit for prior LMAL work experiences equal to the first two years of a stipulated four-year apprenticeship. They spent the next two years in an accelerated program that combined continued learning on the job with the acquisition of related scholastic credits.

Arrangements were made for this initial cadre of 14 to be taught mathematics, physics, metallurgy and other applicable subjects at night...without compensation in a sparse classroom created in a warehouse near the LMAL production facilities. Their instructors were NACA engineers who volunteered...or perhaps were coerced by Percy Crain...to help. They also participated without pay.

On February 4, 1943, the first NACA Apprentice School graduating class in history received their diplomas. The ceremony, held in Langley Field's Post Theatre was presided over by the Langley Memorial Aeronautical Laboratory's Director. Underscoring the significance of this event, the principal speaker was the Federal Government's Director of Apprenticeship, nationwide. Charles Hulcher had the happy task of presenting certificates to each of the graduates.

Speaking on behalf of the graduates was Caldwell C. Johnson, Jr.

**Caldwell C. Johnson:** He was a member of the first class of apprentices at LMAL, and perhaps the most famous of all NACA apprentices. Born and raised in the Wythe area of Hampton, his early fascination with aviation was fuelled by watching military aircraft take off and land at nearby Langley Field.

The model airplanes he built were so exquisite that he was hired in 1937 at age eighteen by NACA as a model builder. But he...and NACA...soon learned that his aptitude was mechanical drawing. While working in the rudimentary drafting room at LMAL [depicted on the right before World War II], he was selected for apprenticeship and was the only mechanical draftsman in that first graduating class.

Caldwell Johnson's talent was later appreciated by Max Faget, a brilliant engineer and a leader in creating America's first space vehicles. Faget and Johnson made a perfect team. In Max Faget's own words:

"Caldwell has an intuitive understanding of load paths and structures which I'd put up against the best structures people in the world. In finding a better way to design something to take the loads, he's superb."
"He has the ability to work rapidly to turn a fundamental idea into a sketch… Caldwell knows what the shops can build, and how well it will hold together, and this is infinitely more valuable than designing something that may look like a masterpiece but will fall apart. He is the only person in the industry that does not use a CAD system"

When they collaborated on the conceptual design of what was to become America's first spacecraft in 1958, it was Johnson who established the vehicle's basic layout. He produced a preliminary sketch [depicted below] which is easily recognizable as being what is now famous, worldwide, as the Mercury capsule that launched America's manned spaced program.

During a 1998 interview about the early days of the space program, Caldwell Johnson talked candidly about the development of the manned space program.

When asked by the interviewer about the use of animals before a human was sent into space, Caldwell Johnson offered the following humorous memory:

"Remember Sam...the monkey Sam? He more or less just went along for the ride, but I wrote a memo and suggested that if you could teach a monkey to do this sort of thing, then you could surely teach an astronaut.

"It was meant as a joke, but the crew people didn't take kindly to it. I wonder why..."

Caldwell Johnson [right] is a co-holder of the Mercury spacecraft patent, plus seven more. When he retired in 1974, this member of NACA Langley's first apprentice school class had risen to the position of Chief of Spacecraft Design at NASA. After many years of aerospace consulting work, he and his wife returned to the Virginia Peninsula in 2008 to live. Caldwell C. Johnson, Jr. passed away in May 2013 at age 93.
**Apprentice Program Refinements:** During 1943, a Federal Committee on Apprenticeship mandated that NACA apprentices receive at least 150 hours of related scholastic study each year. Since many of the apprentices already had some higher education credits of an equivalent nature related to their assigned trade, LMAL received approval to conduct exempting exams for students wishing to avoid repeating courses they had already successfully completed elsewhere.

Initially, the apprentice program featured three terms of study, each lasting ten weeks. Summers were devoted to working full-time in various shops at NACA Langley. Classes were held in the evenings, twice a week in makeshift classrooms within the confines of the Langley Memorial Aeronautical Laboratory. Facility staff, including both engineers and tradesmen served as instructors. Neither students nor instructors were paid for their evening efforts.

Although these classes were primarily intended for those formally indentured as apprentices, prospective apprentices and other LMAL employees - male and female - were permitted to attend the classes. Subject matter included Shop Math, Mechanical Drawing, Blueprint Reading, Shop Theory for various trades, Metallurgy, Physics and Sheet Metal Layout.

By the 1943 fall term, following a survey of the apprentices and with input from the volunteer instructors, classes were moved to nearby Hampton High School. In addition, classes were held in a warehouse building at the lab in the early afternoon for those apprentices assigned to second shift. The curriculum began to reflect advances in technology related to aeronautics. Courses in Simple Aerodynamics, Electricity, Plastics and Radio Fundamentals were added.

Exempting exams continued to be provided. New apprentices were often young men already employed at NACA Langley who were given the opportunity to become apprentices when openings resulted due to graduations or transfers.

**Associated Activities:** In March of 1943, a group of what had already become referred to as 'LMAL Apprentices' formed a social club. Their unabashed and apparently singular purpose was to sponsor dances and parties for its members and guests to relieve the tensions of wartime. Arrangements were made to use the American Legion Hall in Hampton as a meeting place.

Another group, formed in 1942, enjoyed wide-spread participation by not only apprentices, but also many of the young engineers at LMAL. This organization sponsored contests for free flight models and was named, appropriately enough, the Brain Busters Model Club. Their hobby, of course, was a natural extension of the work being performed at NACA Langley during World War II.
The vintage photo on the right was taken in 1943 of some of the club's members; at least two of whom are sporting 'Brain Busters' tee shirts. Individual identifications were not preserved. But one them may well have been Sal Taibi, a young Brooklyn lad whose nationwide fame as a builder of award-winning free-flight models led to an apprenticeship at NACA Langley.

Decades later, Sal Taibi recalled some good times...and bad...in the 1940s.

"I was offered an apprenticeship in tool making, which I accepted. My starting salary was $1,260 a year [roughly 60 cents an hour]. I had only been at Langley for three months when Japan hit Pearl Harbor.

"The programs at Langley changed from a casual research effort to an all out effort for the design, modification and flight proofing of our military aircraft. All the draft age men there were placed in the Army Reserves on an inactive status. This kept us out of the draft and also discouraged voluntary enlistments.

"A fellow modeler married in 1943 and brought his bride to Copeland Park [a World War II housing development near Langley Field]. In early 1944, his wife's sister came to visit. After a whirlwind courtship, she and I were married, and for a time we too lived in Copeland Park.

"In 1945 we got bad news. The reserves were being called to active duty. While I was in basic training, Germany surrendered. Before I was sent overseas, Japan surrendered.

"After finishing my service obligation, I didn't return to Langley to complete apprenticeship. Instead, I, took a machinist's job in my wife's Indiana hometown. In later years, I took a job in California and continued to design, build and fly model airplanes".

At the end of World War II, NACA stated publicly that organizations like the Brain Busters Model Club, which had fostered and encouraged model building, had been vastly important in improving the capabilities of the government's model builders in the national defense effort.
**LMAL Graduation of 1944:** That year, 32 young men received certificates signifying their satisfactory completion of the apprentice program's requirements. Trades represented were Model Maker [4], Tool Maker [2], Engineering Design Draftsman [9], Instrument Maker [1], Metalsmith [4] and Machinist [12].

Suitable invitations [left and below] were issued to high ranking NACA and other Federal officials, as well as the entire mechanical staff at LMAL. In addition, at the ceremony a group of new employees were inducted into the apprentice program at NACA Langley.

Charles Hulcher, Apprentice Administrator, cited the graduates as an outstanding group of LMAL workers. He added:

"They are studying on the job and producing vitally essential war work. All of their related study has been accomplished on their own time. They have sacrificed a great deal of personal pleasure to regularly attend classes and have spent many hours in outside study".

The new class of apprentices inducted at those ceremonies raised the school's total enrollment to 161. Exempting exams continued to be offered to all students whose work or outside study experience indicated a possibility that they could pass such tests. In mid-1944, the NACA Langley's apprentice administrative staff also arranged for an outside educator to conduct a course in the best methods of instructing students for the 25 shop instructors at LMAL.

In addition, a unique program with the somewhat confusing title of 'Under Laboratory Apprentices' was put into place at LMAL during the war. Not part of the formal apprentice program, this effort entailed bringing in high school students two nights a week to work in the machine shop [after, of course, being trained and tested in basic machining operations]. They worked from 3:30 to 11:30 PM and received 55 cents an hour. Some of those secondary school students later became bona-fide apprentices at NACA Langley.
The Rest of the 1940s: The graduating class of 1945 totaled 36. By the end of that year, the war-time activities at LMAL had been greatly scaled back, including the apprentice program. For the remainder of that decade, the numbers of new students accepted declined considerably. Consequently, the numbers of graduates dropped, as follows:

- 1946 - 5
- 1947 - 2
- 1948 - 18
- 1949 - 5

In spite of these cutbacks, the apprentice program at NACA Langley continued and even expanded in some aspects, with 66 young men being accepted into the program in 1949. Earlier, in October of 1946, and for the first time, apprentice students and graduates were provided information and given some assistance in continuing their education at the college level.

In March of 1947, the program was generally upgraded. Instead of going to the local high school at night for classes, students were provided instruction during the day while they were 'on the clock' in dedicated classrooms set up in one of the LMAL buildings [image, right, from a vintage NACA employee publication].

The building selected for this purpose was the facility's Missiles Construction Shop, which indicated NACA's technical progress in the 1940s...from emphasis on piston-driven aircraft to jets...and even missiles. It was a time of rapid technological growth at LMAL, and included the first steps of our nation's space program. In 1948, the facility's first name...Langley Memorial Aeronautical Laboratory...was shortened to Langley Aeronautical Laboratory (LAL).

The apprentices' instructors no longer were unpaid volunteers. A dozen experienced LAL employees served as part-time instructors. Their job descriptions were suitably modified, but there is no indication that they were additionally compensated. The school student census for the 1947 spring term was 103. The list of courses that year included, for the first time, electronics.

An examination of copies of NACA Langley's employee publication, named Air Scoop in the 1940s, reveals a considerable amount of organized athletic programs there. Somewhat curiously, no apprentice teams are mentioned in the many sports-related announcements or scores. Such activities were only department or shop related. Apprentices working in those areas participated in such sports as touch football, basketball, volleyball, and bowling.
Applications, Examinations & Experience Requirements: Because the NACA Langley apprentice program was under the auspices of the Federal Government's Civil Service Program, the process of becoming an apprentice was pretty intensive. In addition, the stipulations for desired experience were unique, by general industry standards, for the NACA apprentice program.

When making application, one or more of the following prerequisites were mandatory in the 1940s for aspiring apprentices:

1) Construction of at least one model airplane which has made a successful flight in formal competition; 2) Winning of an honorable mention or better in formal competition held under the supervision of a national organization in one of the following fields - a) construction of exact scale models of mechanical apparatus, b) construction of working models of mechanical apparatus, c) design of mechanical apparatus; 3) Possession of an amateur radio operator's license; 4) Satisfactory completion of one year of training in drafting, or in one of the metalworking or woodworking trades, or in radio or in the electrical trade in a secondary or trade school of secondary level, or comparable training in an armed forces technical school.

The big benefit, of course, for a NACA Langley apprentice was being paid to learn a skilled trade. In the late 1940s a student received $2,912 the first year, and in the fourth and final year, he would receive $4,160 a year [$2.00 an hour]. At the end of an apprentice's third year, if he had demonstrated suitable aptitude, he might be offered the opportunity to continue in an accelerated course for the next two years. At the end of such a five-year program, he would become a journeyman in one of the more technically-demanding trades.

A part of the application process was a physical exam. However, another interesting...and different...aspect of becoming a NACA Langley apprentice was the fact that a physical disability did not automatically bar employment, as it did in most industries. Presumably, such individuals were welcome in such places as model or radio shops, where physical fitness was not of utmost importance. There also was a written test, lasting about two and a half hours. These examinations took place annually at LAL for a number of years.

The minimum age limit was 16. There was no maximum, which was important to Ben Shrader, whose quest for apprentice training obviously exceeded all others. He completed a boilermaker apprenticeship at NNS in 1957. Several years later, he moved on to the Norfolk Navy Yard where he entered but could not complete their apprentice program due to an injury. In the late 1980s he entered Langley's apprentice school and graduated in 1991 as a Mechanical Engineering Technician. At age 57, he was the oldest graduate ever in that program.
Entering the Space Age: The early 1950s were some of the most exciting times ever experienced at NACA Langley. The rapid-paced development of jet aircraft was followed by missile research and the start of the space program. Activities and expansion of educational opportunities at the LAL apprentice school kept pace. Examples include...based on a list of courses taught in 1952...Calculus, Strength of Materials and Advanced Electronics.

At the start of 1950, the school had 234 students; 202 of whom were veterans. The faculty consisted of 27 instructors. Graduations ranged, year by year in the 1950s from a high of 67 [1953] to a low of 10 [1951]. By the end of that decade, the Langley facility’s apprentice school list of graduates totaled almost 400.

In 1951, 25 graduate apprentices organized the NACA Apprentice Alumni Association. Their goals were to participate in civic endeavors...and to have fun. They were aided in the development and implementation of a charter, constitution and bylaws by Walter Leyland, NNS Apprentice Alumni Association president at that time.

Their first outing was a tour of the shipyard's hydraulic lab, followed by a picnic in the Mariners' Museum park. In later years, they co-sponsored free flying contests with the Brain Busters Model Club. In 1952, the alumni association made Henry Reid, long-time director of NACA Langley, the group's first honorary member. Others who were later honored included Charles Hulcher and Frank Penland.

1953 marked the tenth year in a row that the NACA Langley apprentice school held graduating exercises. Eleven of the first 14 to graduate were present, reflecting, in part, the very high retention rate of graduate apprentices that LAL enjoyed. The 1953 class of 67 members was also treated to a banquet hosted by the school's alumni. And, that same year, class rings were made available for the first time.

Four years later, NACA apprentice jackets were made available for purchase at Spiegel's College Shop in Newport News. In all likelihood these items were displayed near similar jackets created for NNS apprentice consumption.
**NASA:** On September 30, 1958, NACA became the National Aeronautics & Space Administration and LAL was renamed Langley Research Center (LaRC). NASA's colorful logo emphasized space. But the logo's red wing symbol and the word 'aeronautics' in the new agency's title quietly indicated that research of winged aircraft would remain an important mission.

In the early days of NASA, the Langley Research Center [then...and still now...often referred to as NASA Langley] was assigned a leadership role in our nation's rapidly developing space program. Many of the innovations that led to space travel originated on the Virginia Peninsula. Much of the 'behind the scenes' work that made America's space program a success was accomplished there. But in 1962 the spotlight shifted to the then-new Manned Spacecraft Center [today known as the Johnson Space Center (JSC)] near Houston, Texas.

Many of NASA Langley's best and brightest employees were transferred to Texas. One of them was Jack Kinzler. An early graduate of the apprentice program at Langley, he eventually became chief of a huge technical services center at JSC. In that capacity, he solved numerous problems and earned the nick-name: Mr. Fix-It.

When the nation's imagination was captured by the sight of an unfurled American flag planted on the moon's service in 1969, few in NASA were surprised to learn that Jack Kinzler was the innovator. He had suggested that it was possible...never mind that the moon has no atmosphere...to 'fly' a flag there.

He created a telescoping pole assembly and a horizontal crossbar to fit inside a hemmed pocket on the top of a standard 3x5 foot nylon American flag. When erected on the moon, it gave the appearance of a flag flying in a strong wind. Jack Kinzler later said he got the idea from seeing his mother hang curtains in his boyhood home.

Naturally, the government gave his idea a technical name and an acronym: Lunar Flag Assembly (LFA), shown on the right before being placed onboard the Apollo 11 spacecraft in 1969. The flag cost $5.50; the tubing $75.

Jack Kinzler never acquired a college degree. Mr. Fix-It didn't really need one; he had been a Langley apprentice.
**Father/Son Apprentices:** No records apparently exist that reveal how many father/son apprentice 'teams'...or for that matter...even a third or fourth generation served apprenticeships at Langley. What is known is that at least one employee's son, like his father, was an apprentice.

The father, William B. Mayo [depicted, right in 1936] was that NNS apprentice graduate who also was one of the unsung founders of Langley's apprentice program in 1940. William Mayo enjoyed a long and productive career at Langley, climaxed by becoming head of NASA Langley's technical services division before retiring in 1972.

His son, Leonard [left] went to work at the Langley Aeronautical Laboratory in 1954 right out of high school. In December of that year, he took advantage of a vacancy and entered NACA's apprenticeship program as an electronics technician.

Leonard Mayo completed his time in 1959 as an Electronic Instrument Maker and was in the first class of apprentices to graduate after the Langley complex became a part of NASA. He retired in 1989. In a recent interview, he offered the following memories:

"I had no prior experience with radios or other electronics gear. So I had to study extra hard to master the math associated with such things, and to keep up with the other 24 apprentices in my class who had started three months earlier.

"We attended a variety of core courses, four hours each morning, five days a week in a classroom above the West End sheet metal shop. In the afternoons we spread out to various labs and shops for hands-on training throughout the Langley facility according to our disciplines. We were paid for both class and shop work. At the start, I got 72 dollars every two weeks [90 cents an hour].

"Periodically, we were moved from shop to shop to broaden our education in various specialties. In my fourth year, I was assigned to the dynamic force instrumentation group. I liked it there. More importantly, they liked my work and requested that I complete the shop portion of my apprenticeship with them.

"I started out learning how to assemble cables and build chassis for instruments. During my career, I experienced technical transitions from such simple things as vacuum tubes to complex solid state devices. We didn't just build things for testing; we designed and built rugged instruments for use in space. Things that had to survive lift-off stresses and then transmit data flawlessly for years.

"After I retired, following 35 and a half years of service, I worked a few years for a government contractor at the very same job...and at the very same desk!"
William Mayo’s NNS Certificate of Apprenticeship and his son’s NASA Certificate of Completion of Apprenticeship are reproduced below. A close examination of the signatures on Leonard Mayo’s document reveals that one of the NASA Langley officials who attested to his having ‘...satisfactorily fulfilled the terms and conditions prescribed...’ was none other than his father. Few, if any other graduates from either Peninsula trade school likely possess such a rare treasure.
**The 'Cook Book':** During the 1950s and 60s, one of the toughest courses that NASA Langley electrician and electronics apprentices had to take and pass was based on a book utilized by the US Navy during World War II. Entitled *Mathematics for Electricians and Radiomen*, it was written by Nelson Cooke in 1942, a naval officer who had 'come up through the ranks' [US Navy's rough equivalent to civilian apprenticeship] to become a leader in developing electronics schools and training programs for the Navy.

Initially dubbed 'the cook book' by thousands of navy electricians and radiomen, that nickname was adopted by several classes of aspiring apprentices at Langley following the war. It was practical, but included a heavy dose of theory and electrically-related higher math that often challenged those possessing only a high school education.

As Brickey Hughes [right], a 1961 NASA Langley apprentice electrician graduate recently recalled:

"There were seven electricians in my class. At one point, six of the seven, including me, were struggling to pass the course that used the cook book as a text. We had to gather together in the evenings and be tutored by a third-year apprentice to survive."

That extra effort obviously paid off for Brickey Hughes. Including his time in apprenticeship, he worked at Langley for a total of forty years, and rose from apprentice to journeyman and then through four levels of supervision. His was a varied pattern often experienced by other graduates of the Langley Research Center's apprentice program.

His experiences ranged from basic electrical work to being involved in rocket testing at NASA's Wallops Island facility supervising and design development and subsequent construction of payloads for satellites sent far out into space. He also was a subcontracting official for two-three year periods, worked in quality control, supervised wind tunnels' electrical systems' operation and maintenance, and spent a time in an engineering group designing and building support buildings for the Langley Research Center. Brickey Hughes summarizes his well-rounded career as taking place at:

"The best place in the world to work"
**NASA Langley Apprenticeship in the Sixties:** Between 1960 and 1970, the LaRC apprentice program graduated an additional 375 technicians. By 1970, the starting wages for a new hire apprentice was roughly those of a graduate in 1943. The school took on a more permanent look, with classrooms being built on the second floor of the facility's West Area Fabrication Shop.

In 1962, a 1948 apprentice graduate received a Bachelor's Degree in Physics from the College of William & Mary. This achievement was made possible by working nights at LaRC so that he could attend day classes in Williamsburg.

Social changes during that decade led to the first black student being admitted to the program. In the mid-1960s, the total number of apprentices in training often exceeded 250, spread across fifteen different trades. 1966 marked the 25th year of the school's existence. That also was the year when the largest number of students...87...completed their apprenticeship. At their annual graduation ceremonies, it was noted that the program had produced 729 graduates since 1943...and that 80% of them were still employed by NASA at that time.

**Right Place; Right Time:** That's how Charles 'Bud' Southall III characterizes his 37-year career at the Langley laboratory. His apprenticeship, from 1961 to 1965 and his first few years working at Langley as an over-achieving electrical technician overlapped one of the most exciting chapters in NASA's history.

On September 12, 1962, President John F. Kennedy committed the United States to going to the moon before the end of that decade. On July 20, 1969, man first stepped onto the lunar surface.

An indispensable 'preparatory and proof' part of that adventure took place at Langley. Bud Southall [right, in his 1965 graduation photo] was in the thick of those fast-paced and trail-blazing activities. Right place; right time.

His lifelong interest in anything that flies began even before he had become a teen-ager growing up in Hampton:

"My uncle took me for a flying lesson on my 12th birthday and I was hooked. I have flown ever since.

"I also built and flew model airplanes, which led to a chance to apply at the Langley apprentice school. When I took the entrance exam, there were probably 300 guys there, competing. I scored high enough to be one of the 20-30 who were offered an apprenticeship. I chose to become an electrician.

Unlike many others, Bud Southall found math to be an easy subject. He went to college at night, taking advanced math courses. He soon was able to parlay his advanced mathematical education in the Apollo program. Right place; right time.
Assigned to work at the Lunar Landing Research Facility (LLRF) as an electrical technician, Bud Southall found an unique opportunity to usefully combine his flying knowledge and self-acquired math skills. He successfully translated NASA engineers' ideas into practical, computerized control systems that were eventually used by the Lunar Landing Research Vehicle (LLRV). That was a role not thought of as being within the capability of a graduate apprentice technician.

"I was able to use the calculus that I had acquired on my own, plus my knowledge of flying. Pitch, roll and yaw were concepts I understood and could computer model."

A prototype of the LLRV was exhaustively tested at the soaring LLRF in simulated moon landing conditions, as depicted on the right.

"When we tested the LLRV, people showed up for work at 6 AM and often voluntarily worked long into the night. It was a great experience that no one wanted to miss."

Right place; right time. And like the astronauts who trained there, Bud Southall had the right stuff. He moved into a supervisory role in 1973, and for the next quarter of a century advanced up NASA Langley's management chain until he retired in 1998. During that time he participated in the replacement of World War II electrical and electronic systems with solid state equipment.

His last position was Chief, Facilities and Support Systems Division. He was in charge of and responsible for facilities at LaRC that included the electrical transmission network for both NASA Langley and the adjacent Air Force Base, multiple laboratories and shops, and one of the more interesting and demanding jobs for electricians...not just maintaining but operating the wind tunnels and labs.

Not bad for an apprentice who never found the time to become a degreed engineer. But now, in his early seventies, Bud Southall plans to get that long-delayed college degree in the near future. Right place; right time...

**Competition:** The strong desirability of being selected for apprentice training at the Langley Research Center is reflected by the following statistics from 1970:

- Number of applicants who took the written exam: 340
- Percentage of applicants that passed the test: 40%
- Number accepted into the program: 8% [28 students]
The 1970s and Early 1980s; the Good...and the Bad: In 1971, NASA Langley initiated a co-op program with nearby Thomas Nelson Community College (TNCC). A female machinist was one of the first to participate in that educational transition. In addition, individuals interested in a technician career at LaRC were encouraged to attend college-level classes at TNCC on their own and acquire credits before applying for apprenticeship.

NASA was well into the space age by 1970, following the first moon landing the year before. Nevertheless, many of the activities at the Langley Research Center still depended on basic machining work, ranging from tiny parts for delicate instruments to massive mountings for testing full scale aircraft and space vehicle models. The image on the right shows one of the facility's several machine shops where many apprentices learned that indispensable trade.

In 1975 the apprentices at LaRC organized a student group called the NASA Student Technician Association. Efforts were also made to create an apprentice basketball team, but that endeavor was either short-lived or unsuccessful. However, the apprentice school did field an 'in-house' basketball team that competed with various departments' teams at the Langley Research Center.

By 1977, the school had graduated two female apprentices and had seven more in training. But in the second half of that decade, funding for all programs at LaRC was severely curtailed. The apprentice program suffered as a result. There was just a sole graduate in each of the years 1975 and 1976. Simple and somber ceremonies for each was held in the apprentice administrator's office.

Even worse, the 'pipeline' was interrupted in 1976 when NASA Langley suffered a reduction in force and hiring freeze that included apprentices. Eventually, NASA realized that was not wise and resumed bringing in new students in the late 1970s. But, of course, that meant there were a reduced number of graduates in the 1980s, including none at all in the years 1982 and 1984. Paradoxically, in between those two barren years, 57 apprentices completed their time in 1983 as NASA celebrated its 25th year.
Educational Changes of the Eighties: In 1980, 86 individuals were accepted into NASA Langley's apprentice program. Unlike most industrial apprenticeship programs, they all had post-secondary educational credits and were given 18 months of credit towards completion of their apprenticeships.

When six apprentices graduated in 1988, the LaRC administration announced that the school's curriculum was to be extended to a six-year program. The technical co-op program, which had become the principal feeder of new students, was also revised at that same time. NASA began to pay for apprentices' tuition at TNCC and relaxed a restriction that had previously prevented sons and daughters of NASA Langley employees from participating in the co-op program.

Advanced Education Examples: Dozens, if not hundreds of Langley's graduate apprentices sought advanced education during the latter half of the 20th century, including two long-term employees at the LaRC. Neither Alvah Moore nor Charles Cockrell, both of whom graduated from high school in 1960 were exceptional students. Neither had planned to go to college, so apprenticeship at the Langley Research Center provided a good alternative.

But working and studying at LaRC during the facility's heavy involvement in the early and exciting years of America's space program caused them to realize the importance of higher education. Before they completed their apprenticeships, both Moore and Cockrell began taking college courses on their own time.

Following graduation in 1966, they continued to work at LaRC and also pursued college degrees on a part time basis. It took Cockrell [left] 18 years to earn a bachelor's degree in mechanical engineering. He followed this academic success with a master's and a doctor's degree in engineering. In the late 1980's Cockrell was selected as NASA's representative in a half year fellowship program at Syracuse University. Following that experience, he said:

"It was the first time I was in college full-time, and it nearly threw me. I was thrown in with some really bright kids. I spent a lot of time questioning whether I belonged there. These kids asked questions I never would have thought of. But after three weeks the tables turned. Old age and treachery beat youth and skill once again!".

Moore [right] earned his bachelor's degree in electrical engineering by working the night shift at LaRC and attending college full-time; one year at Christopher Newport College and four years at Old Dominion University. He later worked on some pretty exotic projects at the Langley Research Center, including what might be done to alleviate concerns about damage to the earth's ozone layer.
Hands-On Traditional Training Pays Off: When NASA’s $100 million National Transonic Facility (NTF) was damaged in 1988, its 25 huge fan blades, powered by a 135,000 horsepower electric motor, were destroyed and had to be replaced. When NASA was unable to find a qualified vendor that could replicate the huge blades and their complex coatings capable of resisting NTF operational temperature extremes, they turned inwards.

Between January and June of 1989, 49 graduates of NASA Langley’s apprentice school and six individuals still in their time worked three shifts a day, six days a week to produce replacement blades. They manufactured dozens of parts for use in forty individual manufacturing steps to create a single blade. A total of 53,000 man hours were needed to replicate all 25 blades. The magnitude of this work is illustrated by the image on the right [note technician in photo].

A Group Achievement Award, depicted below, was presented to those former and then-current apprentices who had put their training and creative abilities to such good use when no other recourse was available to NASA.

The NTF was completed in 1984. Still in use today, thanks in large part to that team of graduate apprentices, it utilizes super cold, highly pressurized nitrogen gas to duplicate flight aerodynamics experienced under extreme conditions.
The 1990's: Further reflecting the need for a more expansive program of training, NASA Langley's system of apprenticeship was revamped and given the name Engineering Technician Apprentice School in the last decade of the 20th century. In 1990, the starting wage for apprentices there was $5.72/hour. That was 9.5 times greater than a student received in 1941.

Also in 1990, the Langley Exchange Council, an employee support group at LaRC, began an annual recognition program for outstanding scholastic apprentices. Apprentice jackets, featuring an appropriate logo [depicted on the right] were presented to two students in the program. Both of them had perfect 4.0 grade point averages.

A press release in April of 1990 also noted that the Langley Research Center was one of three NASA centers supporting a functioning apprentice program. At that time, the LaRC apprentice school's student body consisted of 140 men and women enrolled in what had...by then...been expanded to a six-year program.

Statistics for the class of 1991 reflect a number of social changes amongst program participants since its creation five decades before. Of the thirty-four graduates that year, seven were female and nine were black. Sixteen were married and five had prior military service. One of them was a naturalized citizen.

Fifteen members of the 1991 class had participated in LaRC's co-op program. By time of their graduation, 21 held associate degrees and 3 had acquired bachelor of science degrees. The class grade-point average was an impressive 3.39, with four members finishing their studies at LaRC with a perfect 4.0 average.

Another example of change at NASA Langley is represented by the experiences of Jim Plant, class of 1991, who still works at Langley and is depicted, left. As he recently recalled:

"When accepted into the program, I was 30; older than most of my classmates. I had an associate degree in drafting. Given advanced standing, I completed my apprenticeship in four years. I still had to take some classes and I was rotated from place to place every six months to get a well rounded, hands-on education.

"I ended up in the Atmospheric Science Division, where I was able to pursue a passion for environmental research and testing. After graduation, I performed work outside the lab, often flying as well as traveling to foreign places. Looking back, I have no complaints. I could not have found a better place to work."

"
The LaRC apprentice program celebrated its 50th year of graduation ceremonies in 1992. Forty-three students received certificates that year, bringing the total number of apprentice alumni to 1,344; the majority of whom were still working at or had retired from NASA Langley, as well as other NASA facilities.

In 1994, the director of the Langley Research Center congratulated the 32 apprentices that had finished their time that year, noting that 86% of the class graduated with honors. He added that LaRC was committed to the apprentice program and its growth. But that year, the school only offered apprenticeships to eleven students. Five years later, in early 1999, there was only one graduate.

Even worse, it was announced later that same year that the apprentice program at LaRC was being terminated. The cause was drastic cutbacks in funding for the Peninsula's premier research facility along with transfers of a large amount of work to other NASA facilities. After fifty-six years, one of the primary reasons for the Langley Research Center's continued success was no more...

Thankfully, neither the father of Langley's apprentice program, Percy Crain, nor the school's first apprentice administrator, Charles Hulcher, had lived to see the apprentice program at NASA Langley terminated. Crain had passed away in 1998; Hulcher in 1994.

**An Apprentice Phoenix:** Happily, in 2007 the LaRC's apprentice school program was rejuvenated and 14 students were enrolled. There was a slight name change; the word 'school' was changed to 'program'. In order to graduate, students in the Langley Engineering Technician Apprentice Program, were required to amass a minimum of 8,000 hours of on-the-job training, acquire an Associate of Science Degree and obtain SpaceTec Certification.

SpaceTec is the National Science Foundation's National Resource Center which promotes, educates and certifies candidates for technical employment. Thomas Nelson Community College's Aerospace Program conducted the required SpaceTec core certification exams for LaRC, as well as offering applicable associate degrees to NASA Langley apprentices.

**Bridging the Gap through Mentoring:** In 2007, Jeff Gragg, the sole graduate of the LaRC's apprentice program in 1999, when that invaluable training effort was curtailed, became a mentor for one of the incoming students. Each of those students was required to rotate through fourteen technical areas at the Langley Research Center as part of their hands-on work experience.

In addition, they continued related class work at TNCC that ultimately would lead to completion of their apprenticeship and a Mechanical or Electrical Technology Associate Degree from Thomas Nelson Community College.
1999 graduate Jeff Gragg had volunteered to be a mentor when he learned that the apprentice program was going to be restarted. He explained his reasons for doing so in a September 2007 interview:

"This is not the type of work that can be taught in a few weeks. But this is one of those cases where the student will ultimately surpass the instructor".

In 2013, four young men who had met 21st century requirements were presented with certificates at a ceremony marking the completion of their apprenticeships. Their status was also changed to permanent employee at NASA Langley.

**2014...and beyond:** On Tuesday, July 29, 2014, nine apprentice technicians received their coveted certificates, signifying their completion of the Langley Engineering Technician Apprentice Program. Before handing out certificates, the LaRC director noted that 1,460 apprentice graduates had preceded them.

He also gave much credit for their accomplishments to their mentors; many of whom were there that day. Following the ceremony, graduate Meredith Hartzheim [right], a third generation Langley employee, echoed his sentiments:

"It's a great experience. You get phenomenal on-the-job training from different mentors".

Then she added:

*It feels really great. It feels like a weight off my shoulders".*

Like her peers, Meredith Hartzheim had spent seven years in pursuit of her certificate and classification as a graduate apprentice. In that time, they had all attained an associated degree, acquired SpaceTec Certification and experienced the requisite 8,000 hours of invaluable on-the-job training.

In recent years there has been a reduction in the technical workforce at LaRC in response to the Budget Control Act of 2011. As a result, there has also been a decrease in the number of students enrolled in the apprentice program; to just three, at present. But the Langley apprentice program has endured reductions several times in its 70-plus years of existence, followed by recurring demands and a continuing need for engineering technicians. Currently, the Langley Research Center is revamping the program to prepare for NASA’s future needs.

Already, announcements have been issued regarding future entry into the apprentice program at NASA Langley. While the number of opportunities that will become available in coming years have not been established, there is a commitment for the program to continue for at least the next five years.
**Reflections:** Langley Research Center employees initially established many of the basic building blocks of aeronautics and then were the pioneers in our nation’s space program. LaRC is where a multitude of disciplines continuously advance education and experience through collaborative applied research. It is an unique place where enthusiastic researchers and technicians have teamed for decades to successfully deal with seemingly 'insurmountable opportunities'.

Langley apprentices and alumni have been an integral and important part of the many successes achieved at this NACA/NASA facility in the past. In addition, when missions were transferred from NASA Langley to other NASA facilities, a number of those apprentice alumni were in the forefront of making work and personnel relocations both seamless and successful.

Obviously, the pattern of apprenticeship at LaRC has changed dramatically over the years, reflecting an ever-changing transition from the mostly 'hands on' and 'over the shoulder' training via 'on the job' experiences of young men who studied at night, largely on their own and without compensation to master a basic trade.

But there's still a need for on-the-job training and a role for mentors...who often are graduates of LaRC's apprentice program. Regardless of how sophisticated NASA’s programs may become, there will always be a need for such craftsmen.

William Mayo perhaps said it best in 1970, when he stated the purpose of the various training programs in place at the Langley Research Center during a NASA Training Conference:

"To develop the technical hands and minds of our Apprentices or Technicians to take the Scientists' or Engineers' ideas with the minimum of information, such as oral discussion, sketches or drawings and convert them into the working models or pieces of research equipment to give the professionals the answers they need in minimum time."
**Post Script:** There seems, at least to me, to be a recurring theme associated with technological accomplishments; i.e., the participants are often too busy creating history to record it. Plus, the fact that this unique educational program is still ongoing may be why a comprehensive and concentrated history of the NACA/NASA program at Langley as not been created to date.

So, I've taken it upon myself to provide this modest starting point. I am grateful to several former Langley apprentices who contributed their memories to this cause. Leonard Mayo was an obvious source for me, because he and I were high school classmates before going our separate apprenticeship ways. Thankfully, during our recent discussions, he diplomatically avoided asking why it had taken me 60 years to show an interest in his NACA/NASA life experiences!

**Acknowledgements:** A prodigious amount of information and dozens of illustrations posted by NASA on the Internet contributed greatly to my ability to create this summation of Langley's apprentice program and are hereby gratefully acknowledged. Vintage Langley employee publications like the *LMAL Bulletin* and its successor publications, spanning the years 1942 to 2001, were simply invaluable.

What NASA has provided on the following web site are considered public information. They only ask for crediting the source of images placed on that web site. Rather than include a number of individual credits, I have elected to hereby acknowledge and credit that source in all-encompassing fashion.

http://crgis.ndc.nasa.gov/historic/Air_Scoop_and_Researcher_News

Surely, I have inadvertently left out some important things in the process of condensing LaRC's apprentice program history to just a relatively few pages. For anyone who wishes to explore this subject in more detail, the link provided above will likely keep you busy for hours...or perhaps days...as it did for me!

BL