2002

A Dream Fulfilled: The Replica of the 1903 Wright Flyer at Wright State University

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A Dream Fulfilled
The Replica of the 1903 Wright Flyer
at Wright State University

by Peter Unitt
edited by Dawne Dewey
The 1903 Wright Flyer takes wing at Kitty Hawk, North Carolina.
A Dream Fulfilled

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Photos on pages 9, 13, 19, 20, 23, 24, 29, 30, 39, 43: Dan Patterson.
All other photographs were taken by Howard DuFour and his team of volunteers.

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Dayton, Ohio 45435

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Printed by C & O Printing, Dayton, Ohio

Book design by Jane Baker

ISBN 0-9676359-1-8
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Howard DuFour, a practical dreamer, begins planning in September 1999.
I. A Dream Takes Shape

On December 17, 1903, above the sands of Kitty Hawk, North Carolina, Wilbur and Orville Wright, two bicycle makers from Dayton, Ohio, were the first to achieve controlled, powered flight. Their success was preceded by years of research and testing. Nearly one hundred years later, a group of very dedicated and enthusiastic volunteers worked together for almost two years to duplicate the Wright Brothers’ efforts by building a full-size replica of the 1903 Wright Flyer. The replica now graces the atrium of the Paul Laurence Dunbar Library at Wright State University. The university is a living memorial to Wilbur and Orville Wright, and the Paul Laurence Dunbar Library is home to one of the most complete collections of Wright Brothers material in the world.

The project leader was Howard DuFour, a master machinist whose colorful career started in the 1930s and included photography, wire service operation, wartime service in the production of armaments, and work in the model shops at the Monsanto Corporation and in the Atomic Energy Commission’s Mound facility. In the 1970s Howard’s career led him to Wright State University, where he spent his final “working” years transforming the ideas of faculty and students into functioning hardware, from educational demonstrators to experimental items. As a hobby, he built a number of working model engines and
machines in his home workshop. This helped him to maintain the uncanny ability to coordinate the hand, mind, and heart, an ability that has earned him many accolades during his busy, creative life. Now in his eighty-seventh year, Howard continues to amaze everyone with his energy, ability with tools, and love of life. Building the replica of the 1903 Wright Flyer for Wright State University was a lifelong dream fulfilled for Howard. It also completed his long search for the answer to the question “How did they do it?” For the volunteers who joined him in this endeavor, it was an unanticipated dream and an unforgettable experience.

Howard was first drawn to the Wright Brothers by a photo on the wall of his Detroit Technical High School. In the years that followed, he amassed a great deal of knowledge about their lives and times.

Determined to discover the secret of their ingenuity, dexterity of hand, and willingness to try something new, Howard began building scale models of the 1903 engine for Wright State in the 1980s. Eager to do it right, he became temporarily sidetracked from his ultimate goal of building a replica of the 1903 Flyer by a burning desire to understand exactly how Charlie Taylor, the Wright Brothers’ mechanic, conceived and built the engine. How did Taylor, a machinist like him, without any detailed plans and with only the materials, tools, and technology of the day, build the 1903 engine? Charlie Taylor became the focus of Howard’s research for the next fifteen years. Howard’s discoveries were revealed to the world in his book Charles E. Taylor, The Wright Brothers Mechanician (1997), which provides a fascinating look into the life and times of Taylor and his significant contribution to the success of the first powered flight.

Armed with years of research and knowledge, Howard was ready to tackle the construction of the full-size 1903 Wright Flyer replica for Wright State University. He received a grant from the university through the efforts of Dr. Rubin Battino, retired faculty member of the College of Engineering. He placed a notice in the Dayton newspaper describing the project, asking for volunteers to join him in unlocking the secrets of the Wrights’ invention. The National Composite Research Corporation (NCRC), located in the former Defense Electronic Supply Center in the Kettering Business Park, donated space for the project. Engaged in inventing lighter, stronger composites for all manner of
applications, including airplanes, the NCRC was delighted to share its space with this endeavor. By October 18, 1999, the Project Center was established and equipped with a drafting table, desks and chairs, lighting, shop machines, and long, wide tables on which to assemble the large wing sections. The construction team evolved into about fifteen people, including skilled woodworkers, machinists, and seamstresses, one a direct descendant of a Wright Company employee. Howard unknowingly invited people who had access to some of the unusual items that would be needed, such as flax cord, thought to be no longer obtainable. As much as possible, he insisted on absolute authenticity in the materials, techniques, and talents used to replicate the Flyer.

Accuracy

No original drawings exist of the 1903 Wright Flyer, so the team relied on copies of the Louis P. Christman drawings completed in 1950 under the direction of Col. Edward Deeds, then president of the National Cash Register Company. The drawings represent the best recollections of at least two original participants, Charlie Taylor and Orville Wright, and are based on the “finished” dimensions calculated by Christman from the actual plane hanging in the National Air and Space Museum in Washington, D.C. They contain errors and no tolerances are given for the dimensions of any individual part. Howard interpreted this to mean that the dimensions on the drawings were those of the fully assembled airplane; by fabricating all the parts to a very close tolerance, the assembled end item would easily meet the drawing dimensions. In effect, the replica was “reverse engineered.” Absent any tolerances on the drawings, Howard settled on ten thousandths (0.010) of an inch for all the wooden parts. This became Howard’s “tolerance test.” The volunteer woodworkers who joined the project were all asked if they could work to within 0.010 of an inch; if they passed this tolerance test, they were “hired.” Not only the finished dimensions of the wooden structure were affected by such tolerances; the fabric coverings must also fit perfectly.

Tools and Materials

The tools and materials needed became available, usually through people whom Howard knew and whose respect he had earned over his
A DREAM FULFILLED

lifetime. Howard sought out Gary Stitzel, a commercial sales repre-
sentative for Sears, who supplied all but a couple of the Craftsman
tools needed. Gary wasn’t at all surprised when Howard approached
him. “I have known this man for many years and have heard him talk
so passionately about this project. There was never any doubt in my
mind that he would someday, somehow, make this dream a reality.”

For constructing the wing and body structure, Howard visited sev-
eral area wood specialty companies, such as the Appalachian Mill
Works, north of Dayton, where he was advised that straight-grained
woods like the spruce used by the Wrights would be hard to find. He
was advised that oak and basswood would be suitable substitutes, and
with the aid of his gathering team of woodworkers, Howard found the
pieces he needed.

The Wrights used muslin to cover the wings and rudders. Howard’s
volunteers did the same with the help of a steam iron and ironing board.
The drawings called for the use of flax cord to bind certain parts. One
of the project workers just happened to have a spool he’d saved in his
attic for years. The roller on which the Flyer had moved along its launch
track was a bicycle hub. For this, Howard was led to a bicycle restorer,
who had a box full of hubs. Coincidences? Howard says no. He felt
the guiding hands of the brothers and Charlie Taylor more than once
as he wondered exactly how they had done certain things.

To make the propellers, the team cut pieces of poplar and lam-
nated them as the Wrights had done. Upon learning of Howard’s project,
the Hartzell Propeller Company from Piqua, Ohio, offered to finish
the laminated “blocks” into two authentic-looking propellers.
Wood parts

Fabric
Jack Ohmart solved the problem of bending wood.
II. Turning the Dream into Reality

The first wooden part was made on December 7, 1999. It was one of the interplane struts that would hold the upper and lower wings together. To form the curved parts of the wooden structure, such as the wing ribs and landing skid, it was necessary to bend the wood to conform with a jig. The most difficult parts to fashion in this way were the “end bows” (wing tips). The Wrights used “kiln dried ash, steam bending,” as called for on the drawing. They took it to a local buggy builder on Dayton’s West Third Street. Howard couldn’t find a buggy builder still in business and so bending such wood proved almost impossible at first. Kiln dried wood, which is wonderful for most normal applications, loses its natural pliancy. Various methods exist for bending such wood, but steam bending was not going to work with the wood Howard had been able to obtain.

Volunteer Jack Ohmart, a retired engineer, would use his lifetime of experience and his extraordinary library to solve the problem of bending the necessary pieces of wood. Jack recalled that one of his books explained how to bend wood. Among the processes described were the uses of steam and chemicals to reintroduce wood’s natural pliancy. Tests proved that steam wouldn’t work to bend the landing skid, wingtips, and parts of the canard control mechanism. The answer lay in the use of ammonia. Industrial-strength, 26-degree Baume
ammonia was used in sufficient quantity to fill a piece of PVC pipe containing one piece of wood at a time. Jack sealed the ends of the pipe and let each piece soak for about a week. While it soaked, a jig was made in which to set the wooden part so that while it dried out, it naturally conformed to the jig’s curved contours. Oak was used for the landing skid and basswood for the other parts.

Jack, like so many of the team members, had his own workshop at home where he had amassed a collection of items. One was a spool of linen flax cord, which he had come by in the early 1950s when he tried to make a crossbow that required a 300-pound pull! The cord was exactly what was needed to bind together certain parts, such as the attachment eyes at the ends of each inter-plane strut and the fabric to the rib ends. Jack also had in his varied collection cotton-covered copper wire of the type used in such early electrical devices as radios. (Jack, who was also an amateur radio enthusiast, had made some of his own equipment.) Howard used this wire to simulate the magneto windings on the replica 1903 engine.

Hans Holztrager, a retired wood shop teacher and friend of Jack’s who joined the project, was assigned the cutting of wood pieces from which to form the aft section of the wing ribs. When the “school” approach of using a jig did not work, Howard suggested he use a free-hand technique. Hans tried it and saw that it worked. He was able to make about seventy of the rib sections over the next few weeks. The seamstresses would have to fit the fabric around the ribs. Volunteer Jerry Beech assumed responsibility for the landing skid and the two props, which had to be cut to size and laminated before being turned over to the Hartzell Company for finishing. Jerry worked on many other wooden parts for the airplane.

The drawings made in the late 1940s by former NCR draftsman Louis P. Christman gave the seamstresses all the directions they would get, at least from the Wrights. One of these drawings noted that the fabric used for wing covers was unbleached muslin, identified by the trade name “Pride of the West.” It was 42 inches wide and had a warp and woof of approximately 108 threads per inch. Panels were made by sewing together along the selvage edges several widths of fabric cut on a 45-degree bias to the weaving. No dope (laquer) was used for tautening the fabric after it was applied to the structure. Tensioning was effected by stretching the panels fore and aft parallel to the ribs and laterally parallel to the spars to attain smooth surfaces. The
Jerry Beech, volunteer woodworker

Seamstresses Josephine “Jo” Elliott Lucas (left) and Dawne Dewey

Photo by Dan Patterson
The exact fabric used by the Wright brothers was not available from sources open to the project team. The drawing that called for muslin with a thread count of 108 per square inch was in error; it should have been 180. Even that was not readily available to the replica team. They were able, however, to purchase sufficient rolls of 42-inch-wide muslin with a thread count of 200 at a local fabric outlet. Howard needed this fabric cut and sewn precisely to duplicate the method used on the original airplane. Josephine (Jo) Lucas, Connie King, Gloria Sgro, and Dawne Dewey joined the team and applied their talents to stitching the many yards of fabric together.

The seamstresses soon discovered that sewing the pieces of fabric together on a 45-degree bias to cover airplane wings and control surfaces was not as easy as it seemed, because the fabric had to be fitted around a curved structure. Also, the wings were considerably larger than they had anticipated (roughly 40 feet long and 6 feet wide). Fortunately, the wings were made in three sections, the centers longer than the outer sections. With no instructions other than notes on the Christman drawings, the seamstresses experienced what the Wrights had as they approached each new problem. Straight stitching was easy, and once they understood how to lay the 42-inch widths of fabric on a 45-degree bias with respect to the leading edge of the rectangular wings and other surfaces, the work progressed nicely. When the first wing section was finished and just before it was covered with fabric, those present inscribed their names on the wooden structure. On all six wing sections, at the trailing edge, on both top and bottom, the fabric was secured with 2-ounce carpet tacks, spaced about an inch and a half apart. This took a total of some 1,250 tacks. The last one was hammered in by Jo Lucas the day before the airplane was moved to the library.

In addition to wood and fabric, the other primary construction material was metal: tin, iron, aluminum, copper, and bronze. Raw stock was transformed into accurately machined, polished, and painted parts. In addition to accessories such as the fuel tank, engine magneto, radiator, chain guides, propeller shafts and supports, and "cockpit" instruments, there were any number of mountings, plates, pins, and brackets. Dozens of lengths of wire had to be cut and the ends prepared to accurately fit as either bracing or control wires. Volunteers Jim Arehart, Don Groves, and Howard combined their skills to fabricate these. Jim
Howard DuFour and Gloria Sgro

Gloria Sgro and Connie King
made virtually all of the metal parts for the replica, many of which he had to cold form out of sheet stock into pieces with compound contours. As with other parts of the airplane, they had to find any dimensional errors in the Christman drawings and allow for the absence of tolerances.

Everyone was amazed at how many items could be made today out of materials that are exactly the same as those in the original. For example, the same propeller drive chains came from Diamond Chain in Indianapolis in 1903 and in 1999. In the replica, the sash chain for the wing warping mechanism came from Dill’s Supply and was from the same material the Wrights used. The roller on which the original airplane moved along its monorail was a bicycle wheel bearing, which a cycle repairman in the Miami Valley happened to have. The bicycle steel tubing used on the original was also duplicated for the replica.

For bracing the wings, the drawings called for “#17 W & M gauge hard drawn steel wire with a diameter of 0.054 inch.” The letters W & M stand for Washburn & Moon, one of several standards for steel wire still in use. Other places needed the same type wire in gauges 13 (.091) and 15 (.072). For the replica, Central Steel and Wire in Cincinnati were able to pull the right gauge of wire from a reel of their stock through a die to straighten it, as required for the application. According to Jim, little in this replica doesn’t exactly match the original airplane. By the same token, just as the original didn’t have any turnbuckles with which to adjust the tension in the bracing wires, neither does the replica. This seemingly minor detail is actually a significant testament to the Wrights’ absolute trust in themselves to design, measure, and make things accurately enough not to need adjustment capability. They avoided the expense of turnbuckles. In order to form loops at the ends of wires with which to secure them to parts of the airplane, special tools had to be made. This is typical of what the model maker does to enable various tasks to be accomplished. All of the wires used in assembling the replica were formed with such tools.

One departure from the drawings was necessitated by the fact that the airplane would not be flown and the wing warping mechanism would not be exercised. In order to warp (twist) the outer wing panels, the rear wing spar must be subjected to torsion or twisting. The Wrights correctly realized that doing so would affect the way that the ribs were joined to the spar. This they handled by using “.035 spring steel connecting straps to permit them to move in torsion as the wing warping
mechanism acted upon them.” On the replica, to better take the stress of being suspended, these flexible straps have been replaced with the same solid metal brackets that join all other ribs to the rear spar. Don Groves made the heavier metal parts, such as housings for the propeller shafts and parts for the propeller chain guard mountings.

**Wing Warping**

One of the most difficult aspects of the project was understanding the wing-warping system and how it worked. Wing warping controlled lateral balance; the horizontal “rudder” in front (canard) controlled longitudinal balance, and the vertical rear rudder controlled balance around the vertical axis. Why was it so important to so precisely balance the 1903 airplane?

The Wrights knew they would not consume very much fuel and, except for the movement of the pilot’s body, nothing on the plane would move during flight to shift the center of gravity and throw it off balance. They designed the plane and put the center of gravity exactly where they wanted it, one of several actions they took to optimize their probability of success. They also eliminated engine vibration and propeller torque, made one wing four inches longer than the other, and used skids instead of wheels, to name a few examples. Howard and his team were successful in understanding and replicating the Wrights’ wing-warping system.

Rigging the left and right sets of three control wires to each other through the control cradle, so that each wing could be warped the same amount, required the considerable effort of several people (no one is sure how the brothers did it). Each wire had to be cut to fit, both ends prepared, and fitted for the first “system” check. It took a while to realize the cradle must be “fixed” at the neutral position while doing anything with the wires. After about three iterations, changing the lengths of the six wires, the wing warping worked properly. Several visitors asked us why we didn’t use turnbuckles. The only reply possible was, “The Wrights didn’t.” In the end, it did work as advertised!

**Systems: Fuel, Cooling, Instruments**

Howard himself built the engine magneto and instruments.
tension” magneto in the original airplane was procured from the Dayton Electric Company (DELCO). Manufactured in South Bend, Indiana, it produced 10 volts and 4 amps at 2500 rpm and was driven via an armature driving disc mounted on the armature shaft. The disc sported a leather “tire” to provide good traction as it rotated through contact with the engine flywheel. Howard replicated it exactly.

The fuel tank and radiator were made by “The Tin Man,” who runs a specialty shop in Dayton. His expertise enabled him to make them both of sheet tin with soldered joints and seams. The fuel tank consisted of two concentric cylindrical cans, the inner one holding up to a gallon of fuel (according to the drawing note). Since the dimensions of the tank do not accommodate that much fuel, we know the note is in error. The internal construction of the original radiator included several lengths of speaking tubes, like those used in apartment houses. The interior details are left to the imagination, since the replica radiator is entirely enclosed.

The instruments most useful to the Wrights were devices that could measure the wind speed and the time it took to fly whatever distance they flew. The distance was so short it could simply be measured out along the ground. The Wrights do not appear to have been concerned about their speed on the first flights. The only speed they recorded was that of the wind, simply because it played a greater part in the generation of lift than did the thrust created by the 8–12 hp engine. Average speed could be easily calculated after the fact from measurements of time and distance. Accordingly, the brothers mounted, just to the pilot’s right, three items: a Jules Richard Hand Type anemometer, made in Paris, to measure wind speed; a stopwatch; and a round dial gauge calibrated in metres. The anemometer was connected to the gauge by a shaft, so that spinning of the vanes translated into movement of needles around the dial. A Veeder Root counter was mounted on the engine for cumulatively counting engine revolutions.

The three clustered instruments and the engine revolution counter, as well as the fuel line valve, were all activated by what is referred to as the Horizontal Control Lever, which the pilot could move into one of three positions with his right hand. Although they will never be activated, all these instruments were faithfully replicated by Howard for the university’s airplane.
Bruce Hinkle working on the propeller, also shown at right.

Larry DuFour and his dad

Photo by Dan Patterson
Propellers and Engine

The propellers on the 1903 airplane were unique. The Wrights essentially discounted everything previously published about the subject and relied instead on their own judgment in the design. They even recorded their confidence in the data from their own wind tunnel, which led them to laboriously carve out with a hatchet and drawshave the propellers. They admitted that the ultimate test would come at Kitty Hawk. Their propellers were shaped from three-ply beams consisting of three full-length planks glued together. The two outer planks were fanned to effect staggered end stacking. The tips of the spruce blades were reinforced with lightweight canvas duck glued to both sides, one side overlapping around the edges. Bruce Hinkle, nephew of volunteer Darrell Sevy and employee of Hartzell Propeller in Piqua, volunteered to assist the team in carving the propellers. Howard’s team laminated three pieces of poplar, roughly 8 feet long, from which the propellers were to be fashioned. Instead of using drawshaves, Hinkle used a grinding disc and a set of contour templates to create two authentic looking propellers for the project. He approached the job with enthusiasm and attention to detail.

Because Howard thought it was important to include North Carolina in the project, he asked his son, Larry DuFour, who lives in North Carolina, to build an engine for the 1903 replica. Armed with a set of engine drawings, which he had seen many times while his dad worked on the Charlie Taylor story, Larry set about his task. In consideration of the potential weight and the overall purpose of the replica airplane, it was decided to fabricate the replica engine mostly out of wood. An electric motor was placed inside the engine with reduction gearing to rotate the propellers at about 2 revolutions per minute. Aluminum, oak, and PVC, among other materials, were used to fashion various parts. PVC was used to form the firing chambers external to the engine block. Oak formed most of the engine block shell, and aluminum was used for the legs on which the engine is mounted to the lower wing. Parts external to the block, such as the magneto, were made by Howard. Fully assembled, the replica weighed about 80 pounds, approximately half the weight of the Charlie Taylor engine.
Move to the Library

The installation of the 1903 Wright Flyer replica in the library’s atrium was planned for the fall of 2001. During the spring and summer of 2001, the library underwent a major construction project to replace the skylight over the atrium. Howard worked with the skylight architects, engineers, and safety specialists to design a means of suspending the airplane that passed all tests for safety and stability. Special electric motors, cables, and fittings necessary to suspend the airplane, as if in flight, and the equipment to change the flight attitude were purchased.

On August 6, 2001, the partially assembled 1903 replica was entrusted to the care of a professional moving company, Mayberry Moving & Storage, to make the short journey to Wright State University. Inserting the airplane into the atrium was no small feat. Two adjacent second-story windows had been temporarily removed for renovation work, opening a space approximately 4 feet high by 22 feet wide to accommodate the passage of fairly large objects. Using a large scissors-type lift truck, the team lifted the parts of the replica into the atrium, where the process of final assembly and hoisting would take place. While the plane was being assembled in the library atrium, the WSU Center for Teaching and Learning installed a web-camera, which could be accessed through the school’s web site. It was a marvelous combining of old and new technology that allowed people from around the country—indeed, the world—to witness day by day the same process the Wrights went through to assemble their airplane.
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Assembly

Photo by Dan Patterson
III. The Replica Takes Wing

The original 1903 Flyer was not assembled in Dayton. The upper and lower wings, which were designed with left and right outer sections and a center section, were assembled after being transported to Kitty Hawk. With no convenient workshop or assembly tables at the dunes, Howard concluded, the brothers must have used what nature provided—sand. There was plenty of that in which they could stand the upper and lower wings of each section side by side to connect them with spars and wires. Howard was up against the same problem. He had to transport the airplane to the library and assemble it there. Final assembly would require sewing together the covering on the three wing sections after the airplane was inside the library atrium.

As the team assembled the replica, they paused to think about those days in late 1903 when, in primitive conditions compared to the atrium of the WSU Library, Orville recorded the conditions at Kitty Hawk and his and Wilbur’s progress in letters home and in his diary:

1903

September 23 . . . this year has been one continuous succession of storms of unprecedented severity; the rain has descended in such torrents as to make a lake for miles about our camp; the mosquitoes were so thick they turned day
into night, and the lightning so terrible that it turned the night into day. . . . Besides all those, the sun was so hot, it must have made soup out of the mosquitoes and rain!

October 16 The upper surface of the new machine is completed . . .

October 23 Worked on skids during morning, and after dinner finished putting on hinges . . .

October 24 We put in the uprights between the surfaces and trussed the center section. Had much trouble with wires, which failed to fit.

October 28 We worked today on front rudder frame and uprights between rudder surfaces . . .

October 30 Continued work on front rudder and completed it this evening. Took machine out and turned it about ready for putting on tail in morning.

November 2 Began work of placing engine on machine, also uprights for screws [propellers].

November 4 Have machine now within half day of completion. . . .

[The next day, trouble with the attachment of the propellers set them back about ten days, while they waited for Charlie Taylor to make repairs back in Dayton. Meanwhile . . .]

November 11 In afternoon we put machine on track and ran it out of building to finish some of fastenings of front rudder. . . .

November 13 The wind being very quiet, we took new machine out to add braces to skids and to attach wires to front rudder frame.

November 20 After dinner we put [the repaired propeller shafts] in place and toward evening we were ready to test . . . could not get the sprockets to stay tight on our propeller shafts.

[From the Christman drawings we learned that in the pre-flight engine warmup the propeller shaft nuts tended to become loose. Using their bicycle experience, the Wrights tried cement used to make tires adhere to rims. By heating the nuts and the threaded ends of the shafts, then filling the threads with
melted glue, they were able to tighten the nuts and have them stay tight after everything cooled.]

November 21  Our confidence in the success of the machine is now greater than ever before.

As the volunteers worked on the plane in the library atrium, they encountered challenges, a few setbacks, and success, just as the Wrights did. They could almost feel the wind and hear the waves of Kitty Hawk in the background.

2001

August 6  The atrium is spacious and air-conditioned. The flooring is solid and level. The roof no longer leaks, so the building is impervious to rain and lightning. The nearest large body of water is Wright-Patterson’s man-made Bass Lake, not far from Huffman Prairie. The sun floods the space with daylight. At night the high-intensity lights turn the night into day. Mosquitoes are not permitted in the atrium and the only soup to be found is in nearby vending machines. The airplane arrived today from its construction site in Kettering, was lifted into the atrium with a scissors lift truck, and inserted through a second-floor window, removed for ongoing construction access.

August 7  All the major subassemblies were unpacked and laid out on floor, along with appropriate tools and a few small workbenches.

August 8  First, the center, lower wing section was assembled to include the frame to which the landing skid attaches. Certain machining tasks were farmed out to team members’ home workshops to be completed in parallel with assembly in the atrium.

August 9  The center section received its upper wing, and the outer wing panels, both upper and lower, were attached to complete the wing assembly. This was done by positioning the upper and lower wings side by side as if being stood up in the sand at Kitty Hawk, just as they were in 1903, to enable their being connected with well-sanded struts.

[Rested after a weekend, the team discovered an error. Each wingtip consists of an almost, but not quite, symmetrical piece of wood. The right upper wingtip had been incorrectly assembled and had to be redone. Uncovering the wing
also revealed a couple of broken ribs that had to be replaced, a good thing to do before hoisting the airplane up above the atrium! Meanwhile, the left lower outer wing panel was laced to the center section.]

August 15 Wing panel rebuilt—ready to be recovered; fabric panels cut and sewed together by Jo Lucas for the underside. After lacing of left outer wing panel complete, gaps between laces closed with laborious hand stitching. A trailing edge stiffening wire, deemed to be too long, was replaced. Team member Jerry Beech underwent successful eye surgery. Marion Wright graced the project with a welcome visit.

August 16 Fabric cut for upper and lower surfaces of right wing, rib sleeves sewn into lower surface fabric. Wing trial fitted successfully. Hand stitching of left outer lower wing panel completed by Connie King and Dawne Dewey. Howard noted an entry made in his calendar several months ago: “August 27, 2001, hoist airplane.” The team thought he was trying to tell them something.

August 17 Left outer upper wing hand sewed to connect it with center section. Shop work was done on propellers to prepare them for balancing. Even though this airplane will not fly, the rotation of the propellers, unless balanced, will cause distress to the airplane.

August 20 A busy day. Howard was interviewed by WYSO radio, while the wing repair continued and adjustments were started on one of the propellers. The propeller shafts arrived from Jim Arehart’s home shop, already assembled with the drive sprockets on one end and the propeller fitting on the other. With the accompanying four support pieces for each, a trial fit was made of one side. Dawne and Connie continued to lace wings together. Everyone took time to admire the magneto that Howard made from scratch; in every respect it was a perfect example of the modelmaker’s art. It seems a shame that it will not be seen up close, once the airplane is hoisted sixteen feet up from the floor.

August 21 Both propeller shafts and their supports were mounted between the wings; the electric motor in the replica engine was functionally checked; the ends of suspension cables were readied and one end of each was attached to the airplane. A solution was found for fixing the propeller. The fuel tank and radiator received a coat of paint. All wing sections but the outer-upper have been laced and sewn together; the outer upper has been re-covered and should be ready for attachment tomorrow. The team began to wonder just how much of all this the brothers really had to accomplish at Kitty Hawk.
Dawne Dewey and Jo Lucas sewing wing fabric.

Dawne Dewey (left) and Connie King (right) sewing wing fabric.
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August 24 The “broken” wing section is finished and installed; both propellers have been drilled for mounting on their shafts. They are to receive burlap “socks” on each tip and be balanced, as necessary. Measurements were taken to determine how to connect the motor with an electrical power source. Suspension cables were connected between the aft ends of the skid structure and one of the winch cables.

August 25 A Saturday. With a goal of “first flight” in the atrium early next week, it’s amazing how many small details still have to be taken care of. In some ways, it’s no less nerve wracking than anticipating the morning of December 17, 1903. Nevertheless, confidence in the success of the project is now greater than ever before (cf: November 21, 1903, above).

August 27 The entire team gathered to right the Flyer and pose for a group photo in front of it as the sun streamed into the atrium. At about 10:30 a.m., after Howard explained how this was to be done, the airplane was indeed righted and now sits on its skid with its rear rudder attached. Its next move in a couple of days will be upward into the rarefied academic atmosphere of the Paul Laurence Dunbar Library. Because the replica will be a thing of beauty and wonderment to behold, white gloves are worn to protect it while it is handled. The team is careful not to sit on the leading edge of the wing and to pull gently on the control wires. Howard demonstrates that, except for the gloves to keep it clean, no other precautions are needed. The team is surprised at the replica’s strength and reminded that this really was a utilitarian object, not just something that looked nice. The engine was set in place. The fuel tank was mounted, one set of propeller chain guides was trial fitted between the engine and propeller shaft. The propeller chain guides would not fit properly, connecting the engine with the two propellers. The reason was not immediately apparent. Both propellers were varnished. Bracing wires were cut to fit where required at the leading edge between upper and lower wings, and the wing-warping wires were adjusted to ensure that the mechanism worked.

August 28 After an entire day trying to understand why the propeller guide shafts would not line up properly, Howard decided to check the parts, as made, against the drawing and discovered yet another error in the drawings. Facing the deadline associated with the dedication and the required atrium clean up, he decided to finish the airplane and raise it, even without the capability to turn the propellers, but only until the next suitable opportunity to

Opposite page: The volunteers before the Flyer was hung (top); the Flyer being raised in the library atrium.
lower the airplane and take care of the problem. The last bracing wires were rigged and the wing-warping wires were adjusted, while the front "rudder" assembly was mounted and its control mechanism tested. Tomorrow, the replica ascends into the Library atrium!

"Flying" the Replica Wasn't Any Easier in 2001

The replica went up for the first time on August 29, achieved a height of about ten feet, then started bucking and rolling, apparently in response to the air currents created by the library's air handling system. Library staff and students watching from the balcony held their breaths. The Flyer was carefully brought back to earth, fortunately without damage to itself or injury to any of its handlers. It was not immediately obvious, but since the wing-warping mechanism was free to move and since there was no one to control it, it appeared to be trying to do what it was supposed to do, as described by the drawing note. After an engineering huddle and consideration of different installation options, the team tried to raise the plane again using Howard's original plan, with the addition of a couple of extra stabilizing cables. On the afternoon of September 1, the airplane was safely hoisted to a height of sixteen feet above the atrium floor to applause and cheers. The center of gravity was exactly where Howard said it would be, because "the Wrights put it there!"

Dedication Day

On September 6, 2001, the same day in 1900 that Wilbur left Dayton to go to Kitty Hawk for the first time, the replica was dedicated to the memory of Wilkinson (Wick) Wright. Wick worked tirelessly for many years to preserve the memory of his great-uncles. Inside the huge atrium at the Paul Laurence Dunbar Library, a crowd numbering several hundred gathered with a mixture of excitement and gratitude to witness a very significant moment in the history of the school. University Librarian Vicki Montavon detailed the evolution of the project and recognized the many contributors who made it such a success. Howard received a standing ovation. University President Kim Goldenberg, a former project engineer on the Apollo program that put man on the moon over thirty years ago, paid tribute to the Wright Brothers, their
Dedication Plaques

Virginia Hess, an accomplished artist, was commissioned to create two plaques for the 1903 project. The first plaque, shown here, was a tribute in bas-relief to one of its greatest supporters, the late Wilkinson “Wick” Wright, great nephew of the Wright Brothers. The second recognized the members of the 1903 replica team.

Both plaques hang in the library atrium.

Virginia and Fred Hess, close friends of Howard DuFour’s, also volunteered on the project sanding wing ribs.
great-nephew, Wick Wright, and to the volunteer replica construction team. Marion Wright, widow of Wilkinson Wright, represented the Wright family and commented on how pleased the family was at this permanent tribute to Wick and the Wright Brothers. Team member Jo Elliott Lucas introduced Howard in a way that perfectly echoed the heartfelt sentiments of all the members. Howard introduced the audience to the airplane, which he termed a marvelous work and a wonder, each part carefully crafted and assembled by his “family,” as he had come to think of the team. He spoke fondly about all who had supported, encouraged, and worked to bring to fruition his lifelong dream.

The volunteers reasoned together, experimented until they found what worked, and then moved forward. Often during the building of the airplane team members themselves would come up with virtually anything or anyone that was needed to keep things moving in the right direction, including the use of their home workshops. Howard had an uncanny way of making the Wrights come alive for his volunteers as they sat around the airplane eating their lunch almost every day for nearly two years. The intrepid band of volunteers labored some 5500 hours with unmatched dedication to produce the replica. The 1903 Wright Flyer Replica is a remarkable tribute to Wilbur and Orville Wright, an inspiring symbol for Wright State University, and the fulfillment of a dream for Howard DuFour and the volunteers who created it.
Project volunteers, from left to right: Hans Holztrager, Jerry Beech, Jack Murphy, Jack Ohmart, Darrell Sevy, and Howard DuFour
IV. The Project Volunteers

Woodworkers

Jack Ohmart: “Jack of all trades: master of most”
Jack Ohmart went to work for Delco as a process engineer after his college graduation. He served in the Navy in WWII and in Korea. After the war he worked at Dayton Hohman and Plating. Howard, who worked in the Monsanto Research Corporation’s Wright State University Instrument Shop, would take jobs for Jack’s company. Over the years, they became fast friends, and Jack was one of the first to learn about the 1903 project directly from Howard.

Hans Holztrager: “Always ask questions first”
Hans Holztrager, a wood shop teacher, retired in 1982 and took up lawnmower repair in the summer months. Hans and Jack worked together at Caesar’s Creek Pioneer Village helping to maintain the century-old log cabins. In January 2000, when Jack told him about the fun he was having helping Howard, Hans immediately became interested and showed up for his “tolerance test.” Hans was as surprised as anyone to be asked if he could work with wood to a tolerance of 0.010 of an inch, but he was willing to try, a trait much admired by Howard. “You realize how much fun you’re having working with Howard and how important it really is when you finally figure out what he’s
actually doing. It’s an amazing project, and I’m very glad I had a small part in it.”

Jerry Beech: “Making sawdust by the pound”
Jerry Beech, a retired Air Force N.C.O and a dedicated volunteer for the Boy Scouts of America, was one of the first to join the team. A wood hobbyist, he remembers when a co-worker at Sears, Gary Stitzel, mentioned that he was gathering tools for some kind of airplane building project. “Being a part of something this unique and historical in its own right was something I just couldn’t resist.”

Jack Murphy: “With signs of the times”
Jack Murphy was a part-time Sears employee who had a strong interest in the building trade, including woodworking, which he had taught at a Joint Vocational School in Indiana. “There’s no better way to learn something thoroughly than to teach others.” As he applied this principle, he began to appreciate the finer points of the marriage of hands and mind, especially in that aspect known as joinery. Jack was more than a little surprised at Howard’s “tolerance test.” “That’s a tough standard for woodwork. I thought I was pretty good at joinery, being able to meet a 1/64-inch tolerance, but the idea of 0.010 inch was new to me. I must admit I even surprised myself after Howard showed me how I could in fact meet the standard of measurement on the ribs and frame parts he asked me to make.”

Darrell Sevy: “Making jokes by the minute”
Darrell Sevy became interested in woodworking in high school. In order to take shop courses he had to actually help build the workshop! After a stint in the Navy, Darrell moved to Tipp City and established a small home improvement business. He supplemented his income as a Safety and Transportation officer for Monsanto, where he met Howard. Darrell’s daughter, an engineer at the National Composite Company where the project was based, told her dad what Howard was up to. Immediately fascinated, he realized he had a marvelous opportunity to be part of something really worthwhile.
THE 1903 WRIGHT FLYER REPLICA

Darrell Sevy, Jay Phipps, Jerry Beech, Jo Lucas

Jack Ohmart, Peter Unitt, Howard DuFour
Seamstresses and More

Josephine Elliott Lucas: “Dedicated, intense, happy, always concerned”
Josephine (Jo) Lucas was a great-granddaughter of Robinson Elliott, a Wright Brothers’ employee and a neighbor of Charlie Taylor in 1908. Instead of the typical formal greeting that one expects at the commencement of a job interview, Jo was treated to the now famous “Howard hug” when she first met him. She recalled that it was more like coming to see a favorite uncle. Jo used her creative talents in sewing, woodworking, and problem solving to create the work of art that the 1903 Replica became.

Constance King: “Tireless, loyal, competent, worried”
Connie King, a part-time interpreter of exhibits at Dayton’s Carillon Historical Park, most enjoyed the exhibit hall containing the 1905 Wright Flyer. During her work there she developed an enormous appreciation for the accomplishments of the Wright Brothers. Connie was fascinated with the idea that it was going to take about fifteen people to do what the two brothers and Charlie Taylor did.

Gloria Sgro: “A stitch in time”
Gloria Sgro, an accomplished seamstress, didn’t know any team members, but they all welcomed her. She would find in all of them a sense of togetherness, genuine friendship, and a veritable storehouse of varied knowledge and experience. Gloria learned to appreciate all of these very talented people. The woodworkers amazed her with the quality of their work. Even though she had lived in Dayton since 1963, she knew little about the Wright Brothers. During the project, Gloria grew to know them well.

Dawne Dewey: “Making history come alive”
Dawne Dewey, head of Special Collections and Archives for the Wright State University Libraries where the Wright Brothers Collection is housed, had known Howard and of his dream to build a replica for many years. When it became a reality, she got involved by sanding wing ribs, sewing wing fabric, and lacing together outer wing panels. Working on the replica helped her become more connected to the Wrights, their amazing invention, and their time.
Jo Lucas, Gloria Sgro, Connie King working on the wings.

Dawne Dewey sits on the floor sewing.
Metal Model Makers

Jim Arehart: “Good buddy, skilled, ‘don’t worry, it will all work out’”
Jim Arehart was a co-worker and close friend of Howard since 1974 when they worked at Monsanto. They also worked together in the machine shop at Wright State University. Both master machinists, they provided an unmatched source of creative skills for the students, faculty, and administration of the university. Jim became fascinated with Howard’s relentless pursuit of truth regarding the engine for the 1903 Wright airplane. While he continued to run the university’s instrument shop, he assisted with the interviews Howard made while researching the Charlie Taylor story. He traveled with Howard to the Bicycle Shop in Henry Ford’s Greenfield Village, where together they made the all-important discovery of the “riser blocks” used in the building of the 1903 engine. In 1999, Jim retired just in time to help Howard pursue his dream of building the 1903 Wright Flyer Replica.

Don Groves: “Heavy metal man, we can make it fit”
Don, who heard about the 1903 project during the time Howard conducted research for the Charlie Taylor book, was very pleased to join the team. His business, Certified Service in Dayton, was in the process of relocating when Howard found himself in need of some special long, wide workbenches. Rather than get rid of them, Don generously donated them to the project. They were perfect for laying out the larger parts for assembly. Don was not absolutely sure how the brothers and Charlie Taylor went about doing certain things, given the differences in technology now and then. It became clear to him that accuracy was a key ingredient in what seems to have been a pretty good record for first-time success. Don developed a greater appreciation for the scientific contributions of the Wright Brothers while working on the project.

Larry DuFour: “Like father, like son”
Larry DuFour is a machinist and photographer like his father, Howard. Larry graduated from Clark Technical High School and worked with his father in the instrument shop at Monsanto. He is now supervisor of the engineering shop at North Carolina State University in Raleigh. One of Larry’s hobbies includes taking a quarter-scale model of a case steam engine and sawmill he built to county fairs and other special events to demonstrate to children what it was like in times gone by.
Above: Jim Arehart; below: Don Groves and Jim Arehart
The model-making skills and knowledge he gained from his father and throughout his career served him well in building the engine for the 1903 Wright Flyer Replica.

Assemblers

Jay Phipps: “Talented, hard working, thanks for the memories”
Jay Phipps joined the team in the assembly phase at the invitation of his good friend Jim Arehart. Jay, the recently retired company vice-president of Buckeye Oil and Equipment, rolled up his sleeves and took on whatever job Howard assigned him. Jay loves history, is active in the Vandalia Historical Society, and has worked on several restoration projects. Jay learned a great deal about the first flight and was an enthusiastic member of the team.

Don Yeager: “Reliable, quiet, but ever ready”
Don Yeager served as assembler on the project. Don learned of the project from his son’s father-in-law, Darrell Sevy. Having made a considerable number of model airplanes in his youth, Don looked upon the 1903 airplane as another, rather large model airplane to be assembled. His principal association with airplanes had been on a light aircraft carrier, the CVL USS Monterey, in early 1945. He served as a plane captain (Navy for crew chief) on F-6Fs. After the war, he became a toolmaker. Don finished the nailing and sanding of the ribs and other parts to give them the near-perfect finish upon which Howard insisted.

Peter Unitt: “Definitely Wired”
Peter joined the project in the assembly phase. His career included work as a technician and engineer in the Air Force. A long-time friend of Howard, he was eager to combine his love of history and mechanical skills to assist in assembling the replica. He also documented the project by writing this account.

Friends

Fred and Virginia Hess: “Gracious, committed to excellence”
Fred and Virginia Hess were close friends of Howard’s. When they realized he would be building the 1903 replica, they didn’t hesitate to
get involved. They were put to work sanding wing ribs. Virginia’s interest in aviation first emerged during World War II. As a young artist still in high school, she was put to work at Wright Field rendering silhouettes of different airplanes that would be used wherever Army flyers were learning to instantly recognize friend or foe in the heat of aerial combat. She received flying lessons during this time and has since added to her logbook the enviable entry, Wright B Flyer.

Rubin Battino: “Fundraiser”
Dr. Rubin Battino, Professor Emeritus, College of Engineering, had a unique way of bringing the wonders of science to others. He used items made in the WSU Instrument Shop by Howard DuFour and Jim Arehart in his lavish demonstrations. Rubin was instrumental in enlisting the help of the Wright State University administration in making the 1903 Wright Flyer Replica Project a reality.

Virginia and Fred Hess
### SPECIFICATIONS OF THE 1903 WRIGHT FLYER REPLICA

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<td>Volunteer Hours</td>
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* Only appreciable difference between original and replica
SOME QUESTIONS ABOUT THE 1903 WRIGHT AIRPLANE

See how much you really know:

- How did the Wrights shape their straight kiln-dried wood to make the end bows (wingtips)?
- How did they avoid the use of turnbuckles for keeping all the truss wires taut?
- Where did they obtain the magneto for the engine? How much electricity did it produce?
- What was contained inside the radiator housing?
- What were the three measuring instruments used on the airplane?
- What three types of wood were used in constructing the airplane?
- What kind of fabric was used to cover the wings, canard surfaces, and the vertical rudder?
- What were the radiator and fuel tank made of?
- How much fuel did they put in the fuel tank?
- How did the brothers measure their speed?
- What was the Horizontal Control lever used for?
- Why did they use two propellers instead of one?
- Why were the propeller drive chains crossed?

One question even we have not been able to answer definitively:
According to the drawings, which offer no explanation, the wing-warping wires also acted as "LANDING WIRES." What do you suppose they were?
The Volunteers

1. Peter Unitt
2. Jack Murphy
3. Connie King
4. Gloria Sgro
5. Howard DuFour
6. Victoria Montavon, University Librarian
7. Jack Ohmart
8. Jay Phipps
9. Virginia Hess
10. Josephine Elliott Lucas
11. Dawne Dewey
12. Bruce Hinkle
13. Darrell Sevy
14. Hans Holztrager
15. Don Groves
16. Jerry Beech
17. Jim Arehart
18. Rubin Battino
19. Fred Hess
20. Don Yeager
21. Gary Stitzel

not shown: Larry DuFour
Project volunteers worked some 5,500 hours to achieve the dream of building and installing a replica of the 1903 Wright Flyer in Wright State University's Paul Laurence Dunbar Library.