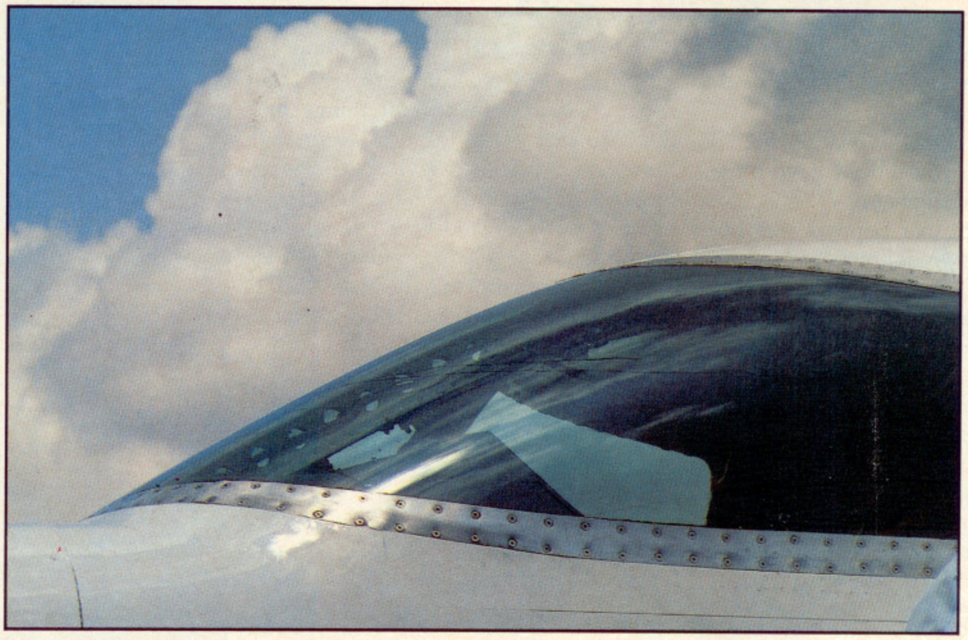

MOONEY 301

Testing, testing. . .

BY EDWARD G. TRIPP

One popular vision of the first flight of an aircraft is of the insouciant test pilot, one hand in a pocket, one grasping the straps of his parachute casually slung over a shoulder, his lips pursed while he whistles the theme from *The High and the Mighty*. He grins at the anxious design engineer, climbs aboard, fires up, gives the international thumbs up and roars off with a victory roll during initial climb.

Then, too, there is the test pilot's typical, laconic after-flight statement along the lines of "She's a sweetheart," or "The flight went according to plan; no surprises."

There is a bit of truth in both visions. However, what most of us do not see or hear about is the meticulous, painstaking—even nitpicking—months or even years of analysis, change and testing that frequently takes place before that first public flight.

The Mooney 301 made its first public flight on April 21, 1983, just about one year later than schedule and nearly three years after the first public announcement of the project. In between were months of optimism, withering discouragement, dashed hopes, financial constraints, late-night negotiations over minute details concerning the location of minor bits and pieces, tons of drawings and redrawings, crossed fingers and anxiety.

Late last year, the fuselage and wings sat next to each other in the experimental facility, finally approaching the day they would mate and become almost an aircraft. It certainly looked like one, at long last, and gave a lift to the remaining core of the design and construction team.

At this point, designer L. P. (Roy) Lopresti (Mooney vice president/engineering, who last year served as head of marketing, as well) and his pretest and flight-test board led by Tom Gailey, head of structures; Rock Peters, M30 project manager; and Carl Mitthe, company experimental test pilot (who left Mooney for the FAA just before the flight-test program began) redoubled their efforts to chart and execute the many checks, tests and analyses that had to be performed before the engine was started for the first low-speed taxi tests. By February, 85 items to check, test, prove, add or change had been identified and organized into a tight schedule.

The thoughts/objectives leading up to the event

Even a fairly minor modification to an existing design involves the establishment of goals; design studies or parts selection to try to change the goals into hardware; assumptions and proof that they will or will not work. For instance, an engine swap that does not involve significant variations in weight, power or other concerns involves a great deal more than remove and replace, and can lead to unexpected and unwanted variations.

To start with a clean piece of paper, as Lopresti did with the MX/M30/301, guarantees a confusing welter of concept, decisions, gambles and blind alleys. As a mental exercise, it can be highly exciting. As an effort to prove, certificate and market a relatively new idea, it is an enormous challenge. When you add the factors of Mooney as a small company that has little available capital with the requirement that new developments be funded

PHOTOGRAPHY BY ART DAVIS

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from sales of existing products, during a recession that was compounded with high money cost and staggering sales decline for the general aviation industry as a whole, you indeed have more than sufficient challenge.

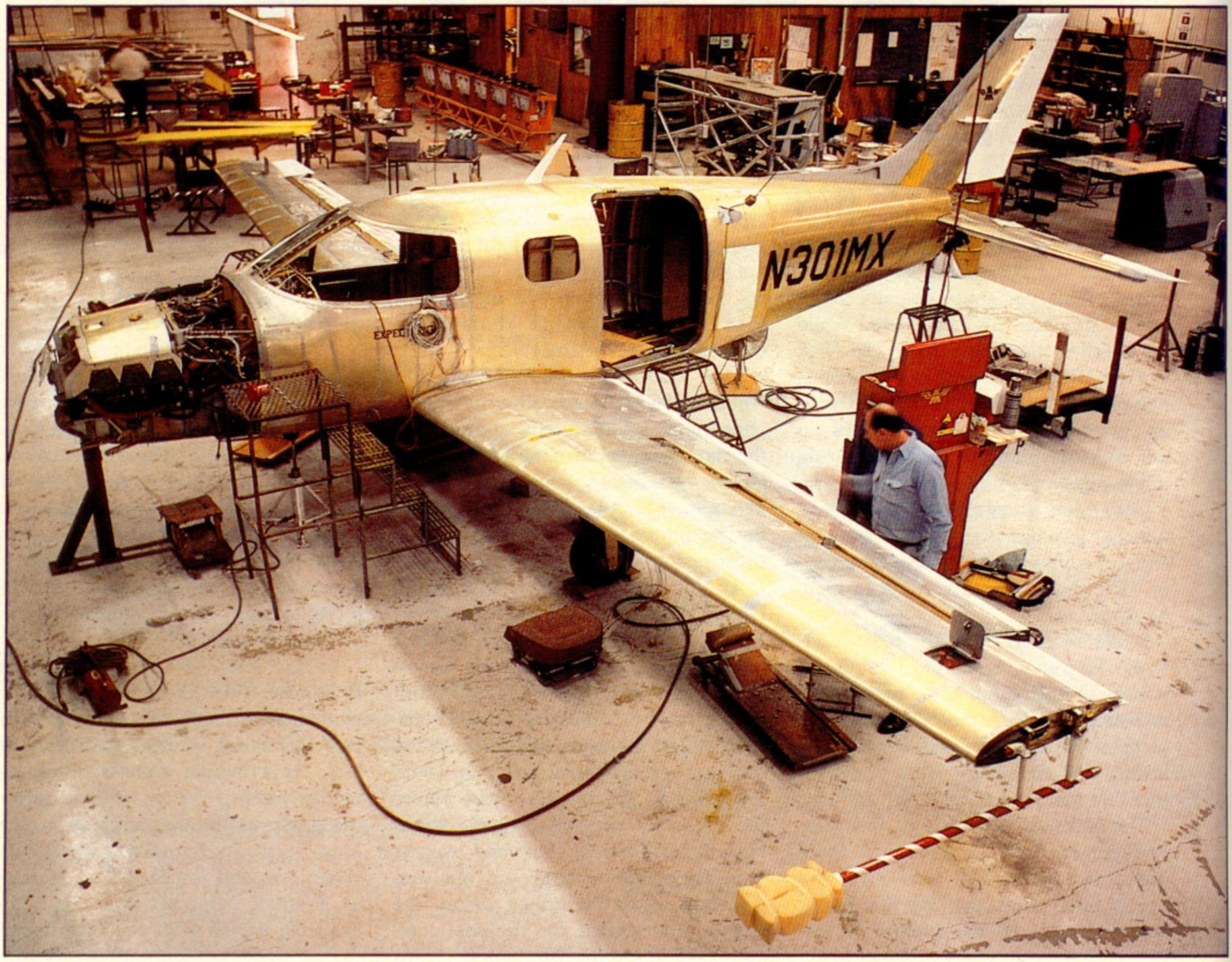
Consider, too, that Lopresti was not after an incremental improvement in performance of existing designs. He wanted to develop the unchallenged high-performance, high-altitude, piston-powered airplane. And, he wanted it to be the most efficient and at the same time an aircraft that the average competent pilot could operate safely. (Perhaps of equal importance was the fact that the management of Mooney and its parent company, Republic Steel, agreed with his concept.)

All designs are compromises. But there are several things that Lopresti did not want to compromise—although there were several things on the M30 that his colleagues convinced him were prudent to give on. He is a designer to whom the little, sometimes expensive, details add up to significant performance improvements that later repay the investment. He also has a highly developed aesthetic sense, which tends to mate with his performance objectives.

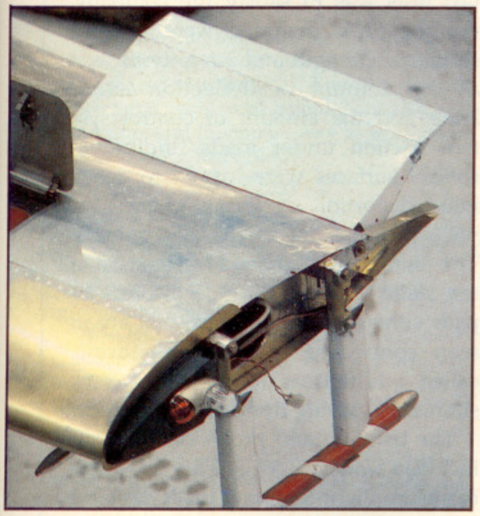
Lopresti distinguishes between minimum requirements (such as FAA certification demands) and optimized ones, and between okay or acceptable characteristics and very good ones. He goes for the latter.

The design objectives for the M30 still are very close to those announced

The first 301 is a company proof-of-concept airplane; in effect, a Mooney homebuilt.



publicly in June 1980 (see "Mooney's Cruise Missile," August 1980 *Pilot*, p. 17) with respect to cruise speed, top speed, range and pressurization. Perhaps it is an expression of his and the company's confidence that the project now is called the 301 (for 301 mph); model numbers have significance for Lopresti. In fact, the only significant change is that the pressurization limit has been raised to 5.0 psi to provide an 8,000 foot cabin at the maximum operating altitude of 25,000 feet, compared with the original 10,000 feet/4.7.



To achieve the goal of a cruise/stall speed ratio of 5:1, exquisite care was taken in flow control of the wings, which wear long Fowler flaps, equally long spoilers and tiny stub ailerons unloaded by anti-servo tabs.

Lopresti also wanted the M30 to have excellent visibility, an improvement in crash survivability and superior flight characteristics. The latter include minimum pitch change with changes in configuration, loading power setting, low stall speed, easy landing, yet high response to control input with low effort and a good relationship between the amount of control input, pressure and response.

Performance and efficiency objectives included minimum drag, a high-technology airfoil, close manufacturing adherence to original design, natural laminar flow (which again requires close manufacturing tolerances to hold the optimum airfoil shape and minimize parasite drag) and maximizing the delivered power of the selected engine.

Lopresti also decided that the aircraft should be close to the state of the art but not too risky—yet clearly better than the competition. This eliminated composites but required a basically conventional metal structure that could hold shapes as well as composites. The next logical step, according to Lopresti, is composites. "The mystery is gone. We could start tomorrow," he says. But the company already is betting a lot on the success of the 301; risk and breakthrough had to be limited somewhere.

When the preliminary design analysis was complete, Lopresti had the basic configuration, shape and power requirements pretty well nailed down: a large, six-place single with a large aft cabin door, a huge windshield, advanced technology, high aspect-ratio wing (using computer-aided design to optimize shape and configuration).

There were a few relatively new angles. Lateral control was to be via a combination of spoilers and stub ailerons. The conflicting objectives of good high-altitude, high-speed and low-speed performance were met with the natural laminar-flow design with Fowler flaps that extend to 90 percent of the wingspan. The goal is a 5:1 ratio between cruise and stall as opposed to the more normal 3.5:1 ratio.

There are construction details that are a result of the need for shape holding and minimum drag without exorbitant costs. The company is expanding the large skin stretch form that has been a manufacturing characteristic of the Mooney wing structure to the fuselage structures as well. In addition, skins are butted, the windows are recessed in routed skins, the door is flush to the fuselage skin, there is extensive flush riveting, and, in general, there is practically no room for variance from design to manufactured product.

One of the biggest gambles is the powerplant. The Lycoming TIO-540, rated at 360 hp, was selected. It has a single (huge) AiResearch turbocharger

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with an intercooler. Lopresti is sure that one large turbocharger is more efficient than two smaller ones. The question is whether the promised power will be delivered at 25,000 feet. Most piston engines suffer installation losses. What is more significant is that neither Continental nor Lycoming have high-altitude test chambers to determine whether the engineering performance actually is available at altitude.

An important requirement in powerplant/propeller was climb performance. After all, you cannot have an aircraft with optimum performance at 25,000 feet if it takes an impractical length of time to get there.

Lopresti, a master at intake/exhaust tuning, has worked hard to minimize cooling and exhaust drag and has gambled on very small intake and exhaust holes in the engine compartment. The design takes into consideration the varying requirements of cooling needs on the ground, during climb, at cruise and in descent.

The result of the design decision and preliminary equipment decisions was a large, tough-but-elegant looking single. If function followed form, the M30 would be a winner.

Just one example might indicate the hard work involved in taking a paper exercise and mock-up close to a working machine. The shape of the high-performance wing includes a carefully shaped, thin trailing edge. It must contain the attach and actuating system for the flaps and flight controls, along with other wires and cables. Space is tight, and it took months of design, negotiation and range wars for grazing land to get everything fit in without affecting aerodynamics and functions. Then, of course, you have to consider accessibility for maintenance.

In time, concept and study were transformed to hardware. Bits and pieces were collected and assembled. Changes were made. Assemblies became major component structures. Then, to complete the circle, all was assembled into an aircraft that still was two months from having the fires lit.

It was time to begin testing all of the assumptions, computer proofs and best guesses of experienced people.

Early in the cycle, it was decided that the prototype M30 would be a company proof-of-concept aircraft as opposed to an FAA-approved pre-production prototype. M30 number one was, in effect, to be a homebuilt.

Mooney decided that the flexibility to check and change concepts and bits and pieces without mountains of paperwork and further FAA-checked tests was preferable to trying out all the ideas within the constraints and possible costs of having it a certification aircraft at the same time.

So the extensive test and proof schedule that was established before the aircraft could be allowed to enter taxi tests was to satisfy the company, not the FAA. Included were tests of structural strength and integrity as well as the amount of deflection under loads and the amount of control system friction under loads. Individual control surfaces were loaded to determine distortion of flying surfaces at yoke pressures of up to 200 pounds. The entire structure was rigged in a test stand with a multitude of pressure pads adhered to the surface that are in turn connected to moveable arms, called whiffletrees. This torture rack simulated varying dynamic flight loads.

The bending and proof loading tests included tests to 2.5 Gs. This was done to ensure flight-test limit loads for crew safety, to double-check stress analysis, to look for any deviations created in the manufacturing process and to test certain load path assumptions made during the engineering phase. Static

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load testing and bending tests included adding shot bags to the structure.

Drop tests were conducted on the main and nose landing gear, and side load tests were conducted on the vertical tail to check the structure and the tailcone joint.

In short, a variety of tests, checks and inspections were made to ensure that parts and pieces matched, would do the work they were designed to do and the test-flight crew would not encounter nasty surprises.

At the same time, the final bits and pieces were added to the airframe. Instruments were installed and calibrated. The company flight review board worked on safety considerations and procedures that would apply during ground and initial flight tests.

The fuel system was cleaned, checked, calibrated and pressure tested. The engine was prepared, the oil system checked and calibrated. The flight-test pitot/static booms were installed, checked and calibrated. All systems, including brakes and steering, were rechecked. Retraction and extension tests were run on the gear and flaps.

A final weight and balance test was run and the envelope checked and recalibrated. The engine was run up and static thrust measured; the engine gauges were rechecked and recalibrated. The crew safety systems and flight-test instruments were installed and rechecked.

Finally, when the aircraft was ready to move under its own power, a vibration analysis specialist was brought in to run a week-long series of tests for flutter analysis and to establish the initial flight envelope for flight testing. The airframe is vibrated over a range of frequencies and at different locations on the airframe. A series of accelerometers are located all over the aircraft; readings are recorded for computer analysis to measure torsion and bending and to predict flutter characteristics.

The first pass at the data cleared the M30 for initial flight tests at speeds up to 150 knots. Further analysis cleared the aircraft for flight up to an Vne of 260 knots.

After another series of checks and inspections, the FAA was called in to evaluate this interesting homebuilt and grant its Experimental certificate. The aircraft was cleared to begin low-speed taxi tests. Many characteristics are measured at this phase: cooling, handling and bending, and torque loads on the

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Most designers watch the first flight from the ground. 301 designer Lopresti watched from the left seat of the airplane.

airframe, gear and engine mounts. Nineteen major areas were measured during each test. A variety of limits and conditions were established.

As each milestone was reached, the aircraft, engine, accessories and systems were inspected.

High-speed taxi tests, which were constrained because of the relatively short runway at Kerrville, Texas, followed under carefully controlled circumstances. Toward the end of the series, the aircraft was accelerated to lift-off speed and, finally, flown in ground effect for a short distance.

The major items being measured during these tests were steering, rigging, directional, lateral and longitudinal control, braking action, engine operation and cooling, and aircraft acceleration. Critical speeds were being recorded.

Each time that the aircraft went out for taxi tests, it was returned to the hangar afterward for more checks, analysis and tweaks.

Finally, the aircraft was cleared for its first flight on April 2. The test pilot for the flight was Lopresti. This broke a tradition, at least for aircraft destined for production; the design engineer traditionally sits on the ground while some intrepid pilot does the flying. Truth to tell, Lopresti wanted to make that first flight under any circumstance.

The M30 now has made several test flights and its first public flight, all according to a carefully developed plan. It has reached 12,000 feet and has been cleared to explore the full-performance envelope. Its basic characteristics for normal flight (not including high-altitude cruise and stalls) have been explored in carefully scheduled increments. The first phase of flight testing has been completed and the aircraft has been returned to the experimental hangar for a thorough evaluation, the addition of more flight-test equipment and gauges and instruments to measure and verify loads, temperatures and other engineering assumptions. Equipment also will be added to excite the aircraft's flight controls for further flutter analysis.

What has been presented here is a capsule of the many things required before the M30 made its first flight. To list all the steps that had to be taken to check, test and verify all the engineering and manufacturing assumptions would fill an entire magazine.

After the next series of checks and analyses is made and the new test equipment is installed, the M30 will undergo at least another six months of evaluation. Only then will enough experience and flight-test data have been collected for the company to make the real decision to continue with testing and a full certification program.

Somewhere during the next series of tests, the company will commit to the construction of a pre-production prototype aircraft.

According to designer/chief engineer and experimental test pilot Lopresti, the aircraft has done what was expected of it. With a few tweaks, the handling is as desired. Engine performance and cooling are good. It is easy to land. More will be known once the high-speed/high-altitude envelope is explored. But Lopresti continues to emphasize that, not what the airplane does, but how it does it—primarily low pilot work load—is what he is after.

For now, he is very happy, as he walks toward his unique homebuilt, one hand in his pocket, the other grasping the straps of his parachute. His lips purse as he whistles the theme of *The High and the Mighty*. □