Low wing test model is pitched in a spinning mode into the spin tunnel at the NASA Langley Research Center. Models can be maintained in a spinning airborne mode for several seconds in the tunnel by regulating the tunnel's air flow as the model rises and falls. To obtain spin recovery data, a magnetic system can release the model's tail control surfaces, after which the model should stop spinning and dive into the tunnel's bottom not. The ability to recover can be tried for various tail designs.

Business Flying

Models, Varied Tails Aid Stall-Spin Work

By Craig Covault

Hampton, Va.—Stall-spin characteristics of general aviation aircraft are being studied at the NASA Langley Research Center here in a program that began tests with a radio-controlled model this month. The research will move to a phase this summer involving a variety of tail designs on an early version of the Grumman American Aviation Corp. Yankee aircraft.

The stall-spin research is one of a number of study efforts under way at Langley with application to general aviation aircraft (A.W.S.T Jan. 20, p. 55; Feb. 3, p. 58).

Langley's general aviation stall-spin program utilizes three main test articles: small wind-tunnel models, radio-controlled models and full-scale aircraft to evaluate general aviation aircraft aerodynamics problems involved in the stall and often subsequent spin.

A prime goal of the program is to obtain information that can be used to formulate a new aircraft spin criterion that can be equated to aircraft design, particularly in the tail area.

Specific objectives of the program are:

- Determine the spin and recovery characteristics of aircraft configurations typical of present-day light aircraft.
- Determine the effects of aircraft mass and center of gravity on the tendency of aircraft to spin or not to spin.
- Evaluate the influence of tail design.
- Determine the parachute and riser length for the installation of proper spin recovery parachutes on test aircraft.
- Develop powered radio-controlled model flight-test techniques for stall-spin and other testing.
- Conduct full-scale aircraft spin tests and correlate the results with model test information.
- Identify parameters that contribute to good as well as to poor spin characteristics.

Current aircraft spin criteria baselines are derived from flight hardware and design philosophy that evolved 20-30 years ago, according to James S. Bowman, Jr., head of Langley's spin research section.

"The industry and the FAA agreed in the late 1940s and early 1950s that they would relax spin requirements, while at the same time the industry would try to build aircraft more spin-proof. Instead of doing that they have diverged. In many cases aircraft are spinning easier and are not designed for recovery," Bowman said.

"The aircraft live up to the regulations; the fault lies more with the specifications, and the specifications were written on what in the past was considered sound philosophy," according to Sanger M. Burk, Jr., project manager for the Langley light aircraft spin research program.

Langley's current spin tunnel facility was put into operation in 1941 and over the years has been used to test about 400 aircraft designs. From information gained during this testing, much of it involving World War 2 fighters, an empirical spin criterion was evolved on how to design the tail of an aircraft.

Since light aircraft now do not look like they used to, Langley is attempting to see how the old spin charts fit the new designs.

"In some cases we're finding they don't fit very well. It's a good thing we're doing this," Burk said. "We haven't done any-
thing in about 30 years on general aviation, so it's understandable we don't have any data now."

Overall program sequence at Langley is to test designs in the spin tunnel, then on a radio-controlled model and then move the testing to a full-scale aircraft.

Langley at present has only a low-wing full-scale aircraft, the Yankee, for this research effort, but program officials are looking for a high-wing aircraft on which to test various tail designs for stall-spin characteristics.

The current stall-spin program is not keyed to specific designs by specific companies, so Langley is taking the approach that aircraft used for stall-spin testing should be prototype or test aircraft in the first place that can be altered by Langley to fit program needs.

"We can't test everything outside that we test in the tunnel. The tunnel models are very small scale, and there is a fair question as to how well they correlate with the radio-controlled model and real aircraft," Bowman said.

Spin-tunnel models have about a 2-ft. wingspan at most and weigh only a few pounds, while radio-controlled models used in the testing will weigh 15-18 lb. The Yankee in typical configuration weighs 1,500 lb., on the light side even for general aviation aircraft.

"We need to know what the technique and correlation is [to know] how you read model data and tell what the aircraft is going to do," Bowman said.

Basic elements that are being monitored in the tests are aircraft center of gravity and the initial yaw moment parameters that provide information on the way the weight is loaded and distributed along the fuselage.

The plan is to evaluate these parameters over a wide range of tail damping power factors, which relate to the vertical and horizontal design of the tail. Tail density is also considered an important factor.

About 8-10 tail designs will be spin-tunnel tested for two individual high- and low-wing aircraft configurations.

"We want to correlate [the existing] criteria to modern aircraft. If the criteria need changing, then we will change them," Bowman said.

The old spin criteria established a boundary so that any aircraft falling on the satisfactory side of the boundary would be expected to recover from a spin. The boundary is not entirely precise, because some aircraft on the unfavorable side of the established boundary will recover from a spin.

The spin program will try to make the boundary between favorable and unfavorable characteristics accurate for present-day aircraft.

"Lots of general aviation aircraft are being designed by the sales department," Burk said.

"To make them sexy looking [the manufacturers] are forcing [their aircraft] down into the poorer regions of the chart. Then it gets to the point where preciseness is necessary," Burk said, although he was quick to point out that NASA is "not oblivious to the marketing facts."

"You have to sell your aircraft too," Burk said.

He cited new tail designs as being a factor in poor spin-recovery characteristics now encountered on many light aircraft.

NASA is working with general aviation manufacturers on the program and obtains permission from specific companies whenever their aircraft designs are tested.

The spin tunnel provides information on the spin itself, but not the initial stages of the maneuver because models are tossed into the vertical tunnel in a spinning mode.

Various tail designs and aircraft loading, representing different fuel loads and other factors, are being tested in the tunnel.

The radio-controlled-model program has the objective of helping to develop this relatively inexpensive test technique for overall aircraft evaluation, in addition to testing within the stall-spin regime.

An initial high-wing radio-controlled model was built at Langley to gain experience that would be used under the more formal stall-spin research program. Before this initial model was damaged, significant experience was gained in utilizing models to obtain stall-spin and other data.

Flying Langley models is not like flying hobby-built radio controlled models because the research aircraft are substantially heavier.

Wing loading on the research models was found to be so high that split controls, utilizing two ground pilots, were devised to keep the vehicles under control in flight.

Because the models are smaller than full-scale aircraft, control motions by the ground pilots must be quicker than with a full-size aircraft.

The program's main thrust now is toward flight testing of the newly built low-wing test model.

The model was constructed at Langley for about $9,000 including labor, although it is believed that if aircraft manufacturers wanted to "farm out" such work to local hobbyists, models could be built for substantially less.

Various aircraft loads and control moments have been scaled into the radio-controlled model as closely as possible to
u(t) = -C(t) x(t)

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duplicate the full-scale low-wing test aircraft.

The low-wing model, complete with deployable spin parachute, can transmit seven data points to a ground receiver which then channels the data to an oscilloscope.

Model data that can be transmitted down during flights includes angle of attack, side slip, and control surface position information.

Each flight can involve about 10 min. of research time with 2-3 min. of fuel reserve for approach and landing. During each flight, about five spins and recoveries can be attempted.

On the radio-controlled model, the spin entry and development can be evaluated, something that cannot be done in the spin tunnel with the models already rotating at the start of each exercise.

90-200 Flights

During the tests with the first radio-controlled low-wing configuration, the four tail designs that will be flown on the full-scale aircraft will be evaluated. Flights for the initial radio-controlled program could total from 90 to 200.

Airframe manufacturers, such as Piper and Beechcraft, are beginning to take an interest in the radio-controlled aircraft test vehicle as an inexpensive way to provide designs with actual flight time.

During testing of the full-scale aircraft to start late this summer, the spin-tunnel and radio-controlled-model information will be correlated with actual aircraft performance. None of the four different tail designs to be evaluated on the Yankee aircraft during its flight program will be the tail originally supplied with the aircraft. The aircraft will be modified to accept bolt-on tail configurations that have been used in spin-tunnel and radio-controlled-model tests.

Other Programs

Program officials hope better low-wing stall-spin criteria will result. It is also hoped that, following the low-wing exercise, the high-wing full-scale test program can be started, and eventually a light twin-engine aircraft program.

Throughout the program, data on the use of spin parachutes will be recorded to establish criteria for the parachute and riser line length that should be used for specific test aircraft.

Additional general aviation program stall-spin work involves the spin tunnel testing of aircraft wings incorporating a significant leading edge droop and later a GA(W)-1 wing (A&WST Jan. 20, p. 55).

Rotary balance and smoke flow testing of the models is also being conducted during the program.

(This is the third and final article on general aviation programs at the Langley research center. Earlier articles appeared Jan. 20, p. 55, and Feb 3, p. 58.)