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Experimental Test Pilot

VMU Tests on A380

Introduction

Almost all pilots have seen astonishing pictures of a test aircraft taking off with the tail scraping the runway with a lot of sparks coming from the rear fuselage during the testing for development and certification. The truth is that a specific tail bumper is added to protect the tail from any damage! But why do we need to do that?

Definition of the VMU

This test allows to determine speeds which are called VMU (Velocity Minimum Unstick). A given VMU is a function of weight, thrust, altitude, and CG. The aircraft actually gets airborne in a similar manner to a Piper J3 (even if not the standard procedure!), with a simultaneous lift-off of the main gears and the “tail wheel”, which is replaced by the tail bumper on the A380. There is no way to get airborne at a lower speed and this is the reason for the denomination.

We need to know the VMU because the computed take off speeds incorporate some margin above VMU, just as they also do for VS (Stall speed), VMCG (Minimum control speed on the ground) and VMCA (Minimum control speed in the air). These “V” speeds therefore form the basic building blocks of take-off performance.

On the A380, there was not only a need to establish the VMU for computation of the take off performance, but it was also necessary to perform some tests at the very



beginning of the development for the optimisation of the take-off aerodynamic configuration. This was done in the first three months of the development.

Optimization of Take-Off Performance

The optimization of take-off performance is complex. Firstly, the aircraft must be able to get airborne safely, even in the case of failure of one engine. It may also have to overfly obstacles, close or far from the runway end, with sufficient margin, still with an engine failed. The optimization has to be performed for all weights, altitudes and temperatures and obviously some compromises have to be made, as no aircraft can be perfect for all conditions. On all Airbus FBW aircraft, the crew has the choice between three take-off

slats / flaps positions: 1+F, 2 and 3. Configuration 3 gives more lift and therefore allows the take-off at a lower speed with a reduced runway length. Alternatively, the minimum deflection, 1+F, gives a lower drag and a better rate of climb with one engine out. It is well adapted to the situation where there are obstacles far away, however, the take-off distance is increased. Configuration 2 is used to cover intermediate situations.

For the optimisation phase, we were able to “play” with slats and flaps deflection and with the size of the strake on the engines nacelle, and we had initially to compare two characteristics: stall speeds and rate of climb with one engine out.

The first stalls were performed on flight 3 with more being carried out in the following days. It allowed us to make a first choice among the configurations to be retained. Globally, the results were very good, even better than expected. The



stalls with a reduced slat deflection were not so satisfactory as it was possible to generate too much side-slip. With the initial position the stall characteristics were excellent. Easy choice!

Without strakes, the stall appeared earlier, with a definite loss of lift. Obviously strakes were needed. We tried several shapes of strake, some with a larger surface, without clear improvement, so we came back to those that had been fitted initially.

The measurements of the rate of climb with one engine out started the first month of flight tests (flights 9 to 12). Again the target was to check that, in all configurations, the performance was in line with the expectations, which proved to be the case.

Finally, for the flaps, we had to make a choice for the configuration 3 for take-off. When coming out of the assembly line, the initially planned deflection was 22°, but in the mean time the aerodynamicists

have found that 26° or 29° would be better. However, after the stalls and the rate of climb measurements, we were still not sure which setting was the best. Therefore we had to perform the VMU tests for a final assessment.

The Difficulties of the VMU Tests

Among all development and certification tests, VMU are probably among the most spectacular for observers, with the small “firework” below the tail just before lift-off. For crew members, they are also one of the most stressful, as the risk of damage to the aircraft is rather high. Few pilots can say that they have performed VMU tests on several programs without damaging anything!

In the case of the A380, some structural reinforcements were made during the installation of the tail bumper so that it could sustain a force up to 160 tons (we reached 100 tons during our tests). Because

the rearmost part of the plane was made of carbon, the bumper was installed slightly further forward in a metallic section. This had adverse consequences, as the protection of rear fuselage was not as good as if it had been mounted in an ideal position. It left a slight risk of contact after take-off behind the bumper. To cover this case, metallic protection was also installed over the carbon in the lower area of the aft fuselage.

There are several difficulties in carrying out VMU tests. The first one is to perform a soft touch down of the tail bumper, as the structure is not designed for a strong impact. This is even more difficult with high thrust and strong acceleration, as there is sometimes not more than one second between touch down of the bumper and lift-off. This particular test, when performed, is done at the end of the sequence, when the crew is well trained and practised in the technique.

For tests with a very low thrust setting, the rate of climb may be very small, and the aircraft could be fly-

ing rather low for a long time after getting airborne. It is also possible that the aircraft can be “caught up” in ground effect where it maintains flight in a kind of “air cushion”, being unable to climb further. In this situation, there is no other solution than to perform a Go Around.

But the key issue is the fact that the regulations request that the pitch attitude must not be decreased below the value at lift-off. To perform a successful test, the pilot generally increases it slightly. However, the margin is only around 1° to 1.5° of additional pitch before touching with the tail, behind the tail bumper. This is the most frequent cause of damage, depending on individual aircraft flying characteristics. There is the challenge!

We need perfect weather conditions, with no turbulence and wind less than 5 kts, to insure the precision of the measurements. Another good reason is that we are flying close to the limits and we must not be destabilized by turbulence.

For these tests, all the audio warnings are “killed” by the crew prior to the test, otherwise the crew receive a stream of continuous warnings: “Thrust not set”, then “Stall, stall” and possibly some others. We must be able to work in a quiet environment.

The Flight Test Technique

The flying technique, as developed by Airbus, is really specific to this type of test and airlines pilots will surely find that rather strange.

The left hand seat pilot is responsible for flying the pitch. His seat is in the lowest position as he does not need to see the runway. He adjusts the attitude using the horizon of the PFD, performing a smooth touch-down of the tail bumper, keeping the tail on the ground until lift-off and maintaining the pitch attitude after take-off until out of the ground effect (one wing span) or 400 ft.

The right hand seat pilot has his seat in the upper position to be able to see the runway even with a high pitch attitude. On the ground, he maintains the aircraft on the runway. When in flight, he keeps the roll close to zero using very small inputs on the rudder (induced roll), and not with ailerons and spoilers to avoid a drag increase. Finally, he is responsible for safety, which means that he can take over anytime, typically if the aircraft is not climbing in ground effect.

The Test Flight Engineer on the flight deck is in charge of setting very precisely the thrust, which is important when we are performing tests at very low ratio thrust over weight.

In the cabin, in front of all their screens, two Flight Test Engineers are monitoring the test, and thanks to the traces, they validate it (or not!).

Now, who is really the Captain? Is it the guy who can damage the aircraft while flying the pitch or the other one in charge of the safety? We have never really decided, but what is important is that the success is coming from a close team work as always in flight tests.

The Tests on A380

As explained previously, the first tests had to be performed rather early in the program in order to optimize the configuration 3. We began on July 13th 2005 at Istres Air Force Base (South of France) where there is a 5 km runway and no houses or other obstacles on the runway axis for several kilometres. It was flight 41 and the first take-off weight was 526 tons (followed obviously later by an overweight landing). Unfortunately, due to traffic then weather conditions we had to stop after only four tests.

During the first test, I was surprised by the reactions of the airplane,

which was different from the simulator, and the metallic part behind the tail bumper touched the runway. The damage was minor and we were able to continue the tests, taking into account the lessons learned from the first one!

The following day, July 14th, was the French National Day. So apart from two KC145 taking off for the parade on the Champs Elysées, there was no traffic and we were able to progress quickly. We exchanged seats between the two pilots. In the mean time, we found a method of changing the protection under the tail bumper without shutting down the engines. This saved time so that eventually seven successful tests were performed, mainly with the two possible settings for configuration 3.

The final result was the choice of a deflection of 26° for configuration 3, but with only a very small difference from the 29° setting. We planned initially four months to optimize the aerodynamic configuration, but all the characteristics were really excellent and everything was completed in less than three months.

Later in the development campaign, some more VMU had to be performed for the take-off performance computations. These were done on March 25th and 26th 2006. Eleven more tests were done in total, including those at very low thrust, down to 48 % of maximum thrust at 440 tons. For this last test we were still at 200 ft about 4 NM from brakes release, when finally we were able to climb out of ground effect!

A total of 22 VMU tests were executed including both development and certification.

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