PROPELLERS COMPARATIVE TESTS IN FLIGHT

Comparing propellers in flight is a very interesting and complex exercise, requiring sophisticated measuring equipment, a very strict protocol, an experienced pilot, stable weather and a lot of time.

1 - Definitions

A propeller is not an accessory. It's the essential equipment that transforms the engine's power into traction for the aircraft. The propeller alone has no performance of its own: it is closely linked to the engine and the aircraft it powers. That's why it's so important for a propeller to be designed for a given engine and aircraft range.

Each propeller provides performance in terms of :

- rolling distance on take-off
- initial climb at the speed recommended by the aircraft manufacturer
- fast, economical cruising (using more or less fuel)

The propeller will also influence :

- aircraft weight, which is of enormous importance for takeoff performance (rolling distance and rate of climb)
- the longevity of the engine and/or its gearbox (the propeller's moment of inertia must be well adapted)
- aircraft availability (enhanced by a solid propeller with a large TBO)
- piloting comfort (vibrations or absence of vibrations)
- cockpit noise (difficult to measure and highly subjective)
- pilot's budget

2 – Measuring equipment

In aircraft, you need the most accurate instruments possible to measure :

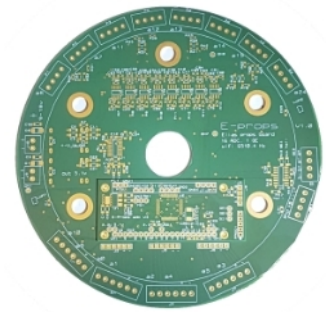
- ✗ engine speed: revolution counter
- ✗ aircraft speed: IAS, CAS, TAS, etc.
- ✗ intake pressure: MAP
  (without MAP, the only points to compare will be full throttle)
- ✗ altitude: altimeter
- ✗ rate of climb: variometer
- ✗ flight symmetry: sideslip indicator

Outside of the aircraft, you must also measure :

- ✗ blade pitch: using a precise pitch adjustment tool
- ✗ propeller weight: using a precise balance to weigh the propeller, including spacer, spinner and all screws and bolts
- ✗ aircraft take-off rolling distance (often performed by an outside observer)

Note:

For in-flight propeller tests, E-PROPS has developed a DAU (Data Acquisition System) called MERLIN, which measures the following parameters at every moment of the flight: propeller traction, propeller torque, T°, static and dynamic pressures, engine speed, intake pressure and T°, incidence and sideslip values.



MERLIN electronic card

3 – Ground-adjustable pitch propeller settings

To compare ground-adjustable pitch propellers, you need the same pitch, which doesn't mean the same pitch, but, for a given optimization point, the same rpm at a given intake pressure.

This optimization point needs to be defined:

- either the propeller blade pitch is set to give the same take-off performance and climb rate, and the cruising speeds (economy and/or fast) are compared.
- or the propeller blade pitch is adjusted to give the same full-throttle level-off speed, and take-off performance, climb rate and cruise speed (economy and/or fast) are compared.

It all depends on the aircraft's operating specifications.

The best thing to do is to compare the propellers at a setting that enables each one to meet the non-negotiable safety criteria, i.e. take-off and obstacle clearance in hot weather, and then compare the cruising speeds achieved by the different propellers.

digital protractor

4 – Conditions for carrying out the tests

To compare propellers correctly, the following tests must be carried out:

- On exactly the same aircraft and engine. We only test the propellers, not several pieces of equipment at the same time, and we don't change anything between tests.

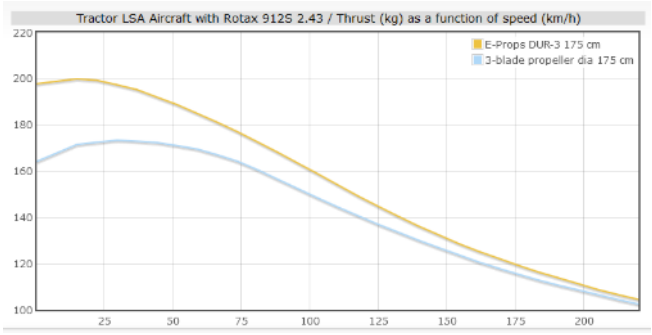
- On the same aircraft, with the same weight, with exactly the same fuel mass. Weight has a huge impact on roll distance and rate of climb. For over-powered light aircraft, such as those derived from aircraft with Rotax 100 hp, weighing down the aircraft by 1% means losing 1% of climb rate. This loss of climb rate is much greater on under-powered light aircraft.

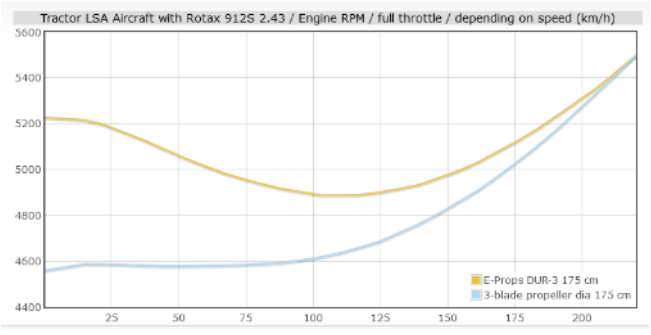
- With the same pilot, for reasons of weight and flying style. Ideally, the pilot should reproduce the same tests, so it's a good idea to have an experienced pilot with no (too many) preconceived ideas about the equipment being tested. It would be best if the pilot didn't know which propeller he was testing, so as to maintain objective piloting, but this is virtually impossible.
  The pilot has to pay close attention to the symmetry of the flight to avoid side-slip, and must carefully maintain level flight to avoid a slight climb or descent.

- With exactly the same weather conditions. Running the tests on the same day seems a good idea, but beware: between two tests, air temperature, pressure and wind may increase or decrease, which can significantly alter the measurements. In the mountains, the slightest breeze and thermal activity will create updrafts or downdrafts.

5 – Data analysis

Once the tests have been carried out, the data must be processed and a detailed report drawn up, complete with tables and graphs. Graphs make it easy to enter and memorize information, and to appreciate the dispersion in the data (confidence index).





6 – Example of propeller test sheet

PROPELLER TEST SHEET	
Date :	QNH :
Aircraft :	Wind on the ground :
Propeller :	T° :
Propeller pitch :	Aircraft weight :

Start time :	Arrival time :

Speed : kts or km/h - IAS or TAS - Altitude :

RPM	Speed	MAP	Fuel flow
	Fixed point		
Take-off distance		VZ :	ft/min
	Full throttle climb		
	Full throttle level flight		
5500			
5300			
5000			
4500			
4300			
4000