



Pilot Knowledge Series

WHEELBARROWING AN AIRCRAFT IS NOT COOL

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Scene 1: A fine day with a light wind blowing across the runway at about 5 knots. A light aircraft is on short finals, airspeed is just a few knots fast and the aircraft, tracking slightly, is astride the centre-line and a bit high. The aircraft reaches the flare point further into the runway than the pilot likes so he decides to get the wheels onto the ground where he will have some braking.

Scene 2: Inside the cockpit the pilot hasn't allowed the aircraft to float as normal to wash the airspeed off. He flares just enough to let the aircraft touch down on the mains and nosewheel simultaneously.

Scene 3: From outside the aircraft the tyres squeak and the aircraft bounces gently. You can see the trailing edge of the elevator move down as the pilot pushes the stick forward to hold the aircraft on the ground. The nose is forced down onto the nosewheel wheel and the nosewheel suspension flexes as the leg shortens. The aircraft has begun to drift slightly across the runway with the crosswind

Scene 4: Inside the cockpit the pilot reaches for the brakes and applies them firmly. Too much of the runway is behind him so he presses the stick further forward and applies even more pressure on the brakes.

Scene 5: The main wheel leg lengths extend as the tail rises and the nose pitches even further down. The main wheels stop rotating as the traction diminishes; the weight has come almost completely off the main wheels. Directional control is lost – falling airspeed has robbed the controls of their effectiveness and any chance of useful differential braking is gone- the braking wheels are virtually off the ground and, anyway, the pilot is too engaged to try to use them. The aircraft continues to drift further away from the runway centreline.

Final scene: The aircraft suddenly snaps and yaws violently, yawing into wind and pivoting around the point of contact of nosewheel with the runway. The nose leg fractures and collapses. The prop strikes the ground and bends backwards as the cowling crumples and tears away beneath engine. The tail and windward wing rise and the aircraft slowly topples tail over nose to lie upside down on the runway. There is silence except for the crackle of bending metal as the wreck settles. There is a strong smell of petrol in the air ...

Wheel-barrowing is a dangerous condition that occurs when the weight of an aircraft becomes concentrated on the nose wheel during a take-off or landing roll.



On take-off, the common cause is the pilot holding the airplane on the ground too long, particularly when a crosswind is present. When this flawed technique is used the forward stick that holds the airplane on the ground by pitching the nose down unloads the main-wheels, transferring the load to the nosewheel. This extra heavy nosewheel loading compresses the nose-wheel suspension and forces the nosewheel to remain in firm contact with the runway. This is *wheel-barrowing*.

In this condition, any yaw will set up a couple that will turn your airplane, and your very world, upside down. All directional control will be lost and the airplane will trip over its nose-wheel.

In reality, there is no cause to keep an airplane on the ground after it has reached its V_x (best angle of climb speed), indeed, there are very good reasons to be airborne before this figure is reached. If a pilot considers that he/she should hold their airplane down until attaining its V_x before lift-off, then the flight should be cancelled or postponed until better conditions exist.

Wheelbarrowing is more frequently an issue during the landing phase. Commonly, it results from approaching too fast and then touching-down too flat. As the rebound from the undercarriage tries to make it fly off again the pilot takes the stick forward to hold the aircraft on the ground. The applied forward stick will pitch the airplane nose down, unloading the main wheels and loading the nosewheel instead. With the aircraft main wheels on tip-toe braking will be lost because the wheels have insufficient weight on the tyres to provide traction for brakes to function. The nose wheel, still in firm contact with the runway, will suffer substantial drag, and any lateral movement will create a powerful couple that yaws the airplane and it will pivot violently about its nosewheel.

To get a grip on this topic, it is necessary to be clear on what a 'couple' is in this sense.

A Couple is a force acting about a point. The magnitude (power) of a couple varies with either a change in the power of the force applied, or a change in the arm of the force. A couple can ONLY be opposed by another couple.



In a 'normal' landing, when the main wheels (PW and SW) touch the runway with the nosewheel (NW) clear, two couples are generated by the contact the wheels have with the runway. The magnitude of each couple is determined by the drag force of the tire/wheel and the length of the couple arm - the distance between the point of application of the drag force and the aircraft Centre of Gravity.

- Assuming the same drag applies to each wheel, when the aircraft is pointing in the same direction as it is travelling the couples are equal (red and blue couple arms are the same length) and no yaw will be caused by this interaction. This makes a nosewheel equipped aircraft easy to control on the runway because it is directionally stable and its forces try to keep its nose aligned with its direction of movement without pilot input. See Fig. 1.

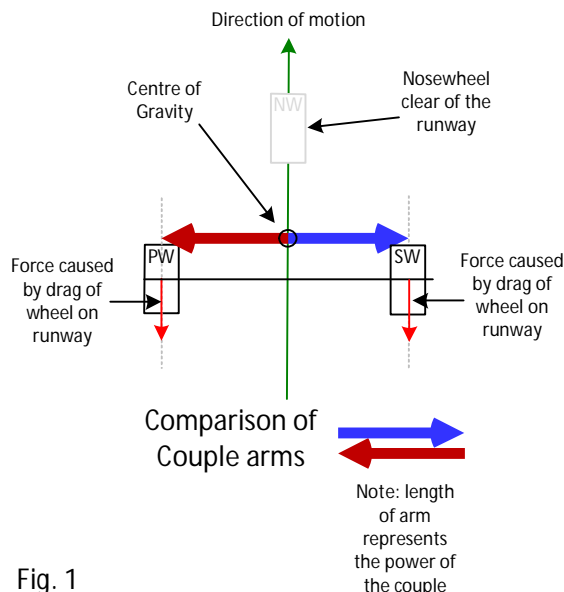


Fig. 1

Using the correct take-off and landing techniques provides a directionally stable aircraft. Drag from the wheels in contact with the runway provides a directionally corrective force.

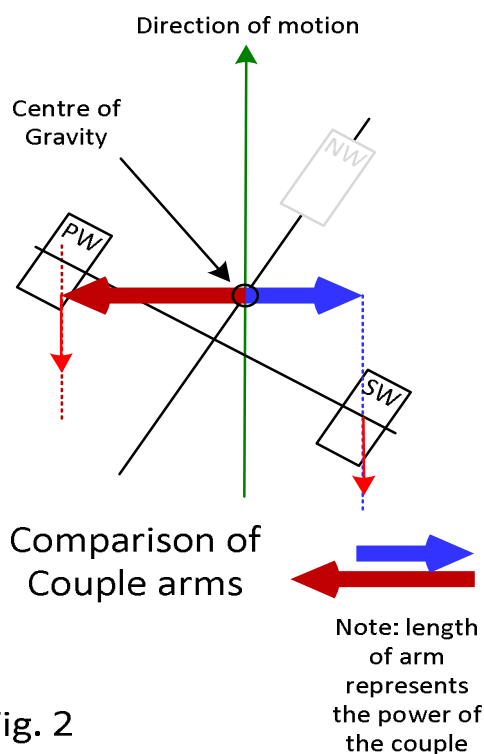


Fig. 2

As Fig. 2 (Left) illustrates, this is a STABLE action because it yaws the aircraft back towards its direction of motion and as it does so the couple arm shortens, diminishing the force as the alignment completes. In other words – the airplane WANTS to move in a straight line. The weight and drag forces tend to keep the airplane moving straight. However, this will ONLY be the case while the main wheels are on the runway and have traction with it. If the main wheels are not in contact with the runway and the load is on the nosewheel, an entirely different situation exists. If, whilst the aircraft has weight on the main wheels, the nosewheel is clear BUT the aircraft nose is NOT pointing in the same direction as the



aircraft is moving, then the couples will not be equal – the leading main wheel will have a greater arm and therefore more powerful couple. This, the red couple as illustrated, is more powerful than the blue couple, and the imbalance provides a force to yaw the aircraft’s nose and align it with the direction of motion.

However, when the nosewheel is on the runway and the main wheels aren’t, the situation becomes critical.

Fig. 3. If, in this state, the drag generated by the nose-wheel is directly aligned with the centre of gravity and the direction of motion, no couple is formed and there is no yaw force generated.

However, immediately the nosewheel diverges from its alignment with the centre of gravity it will instantly create a couple that generates the unstable yawing moment. For example- See Fig’s 4, 5, & 6.

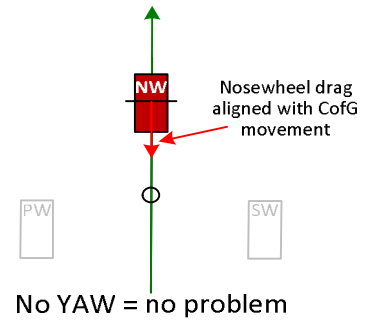


Fig. 3

Fig. 4. If the nosewheel has moved to the right, the drag force caused by nose wheel contact with the runway is now no longer aligned with the centre of gravity and direction of motion. A couple is formed.

Yaw creates an unstable condition that that can quickly become an out of control situation.

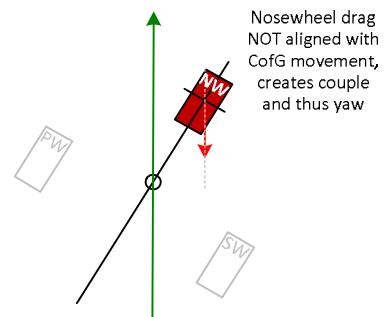


Fig. 4

Fig. 5. The grey force of the aircraft’s mass acting through the aircraft centre of gravity is moving forward while the red drag force created by the drag on the nose-wheel’s contact with the runway acts rearwards. This will savagely yank the aircraft into a right yaw state and, as the yaw takes effect and the angle change increases, the arm gets longer and thus very quickly more powerful.

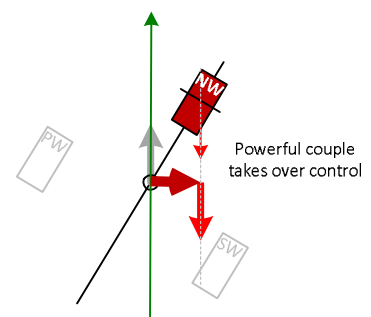


Fig. 5



Fig. 6. The magnitude of the couple has increased greatly with the changing angle. Not only is the arm longer, but the front wheel has less rolling ability and the now scuffing tire has greater drag than it initially had.

The situation is now serious. The aircraft still has just the nosewheel on the runway and the yaw forces are now beyond correction by the rudder. Removing forward pressure on the stick and then adding full power may allow the aircraft to fly off but as curative action it is doubtful at best. Effective control is lost and there are no remedial options available to the pilot at this late stage.

This is, in effect, a ground loop condition and the side loads on the nose wheel assembly will quickly exceed their design limits. The nose leg will fail. The prop may strike the ground and disintegrate.

Parts of the propeller may enter the cockpit with fatal consequences. This can ruin your WHOLE day.

However, on the bright side, the landing will be short!

While the best correction is to never get into this condition in the first place, an immediate go-around BEFORE substantial yaw is experienced can resolve the problem – but early recognition of the pending problem is paramount. The correct landing technique has the main wheels touching first and the nose wheel settling only in such a manner that a positive load is retained on the main wheels as the speed washes off.

As you can see, there are very good reasons for this.

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