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The Weird And Wonderful Airbus Logic

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THE WEIRD AND WONDERFUL AIRBUS LOGIC

In the last few years we have seen that many pilot who were used to Boeing (and more 'standard' logic) have problems understanding the logic of Airbus. We'll try to discuss the most confusing and often illogical aspect in this document.

This is not a highly technical document and people accustomed to Airbus logic will not need it. In fact they might find it lacking in detail or inconsistent. But if you are a real Airbus virgin you will appreciate the information.

AUTOMATION

Almost everything that can be automated is automated and handled without any need for operator intervention. You just tell the aircraft what you want and it will try to do it. This seems logical these days but when Airbus started with this it was a strange concept. A fine example is the window anti-icing systems. As they are fully automatic and we do not spend a lot of time on failures (as far as I could see a serious problem resulting of a failure of the anti-icing system has never occurred in millions of flight hours) we simply do not model them in our simulation. There is no need to. As far as a real pilot is aware they simply take care of the icing issues without bothering the crew.

Airbus pilots call it 'automagically'. You should not always try to understand the logic of the systems (certainly not when you are busy), just accept that the aircraft will try to assist you in every stage of the flight.

FLY BY WIRE

Of course this is the big one and the thing that set Airbus Aircraft apart from others for a long time. It's a simple concept, the pilot talks to the computer and the computer talks to the aircraft, but it has a profound effect on every aspect of the flight. It is best explained by a comparison. As the pilot in a Boeing 737 pulls hard on the yoke the aircraft will pitch up and it will keep pitching up until thing go horribly wrong. If you do the same in an Airbus the computers would try to figure out what you actually wanted and then try to get it done for you. As it will understand you want to go up fast it will allow you to pitch up to a maximum (but still safe) angle and when you are running out of airspeed it will increase thrust to TOGO (Go Around, the maximum amount of thrust possible). When even that does not keep enough air going over the wings it will lower the nose to increase speed. The FBW systems also prevent the pilot from doing silly things like stalling the aircraft or doing barrel rolls.

The controversy between FBW pilots and non FBW pilots will probably never end. There is a lot to be said for each philosophy. While FBW will make flying inherently safer by preventing mistakes it also limits the option a pilot has to get out of a bad situation. There is one fine example of a situation where the automation helped. During the US Airways crash in the Hudson the pilot had to ditch with minimal ground speed and minimal vertical speed. To do this he simply had to pull the control fully back. The aircraft knew the weight of the aircraft and the environmental conditions so it knew the stall speed. It sensed the stick being pulled back fully but as it had no running engines it simple selected the best option and that was to slowly descend at a speed just above stall. In a Boeing the pilot would have to very carefully maintain that minimal speed until touch down. That is difficult in a normal situation and neigh impossible in an emergency.

Another very important aspect of FBW is that when the pilot does not give any input the aircraft will stay on its current flight path. Best explained with an example. Take an Airbus up to 5000 feet, bank it a bit and let go of the side stick. Then go have diner. When you come back the aircraft will still be at the same bank and making large circles in the sky. A non FBW aircraft would be flying a straight course and it would level out. This may sound not too important, but consider what happens when you extend the gear. That increases drag and because they are positioned below the CoG they will cause a pitch down movement the pilot has to correct. In an FBW aircraft this would happen automatically and the aircraft would not pitch down.

In very simple terms: When you point a FBW aircraft somewhere it will go there as long as it has enough energy.

DARK COCKPIT CONCEPT

Airbus understood that the modern cockpit crew has a huge amount of information to process. To help with that the cockpit is designed with the 'dark cockpit concept'. Basically it means that if a system is running normal there is no indication. No green light, no pressure indication, just nothing. Only when there is an abnormality will the system try to draw your attention. Even when there is a problem and the systems were able to sort things out it might not be shown until the flight is over! These days Boeing also adheres to this concept in the 777 and to some degree in the MD11.

Of course some control do need to give some feedback and this is done in green (all okay) and blue (still okay).

THRUST LEVERS THAT ARE MODE SELECTORS

The thrust levers might be big and obvious things in the Airbus cockpit but they are hardly used. In a standard flight the pilot only touches them a few times:

- TAXI: the thrust levers behave like normal Thrust Levers.
- TAKE-OFF: Pilot advances the thrust levers to the FLEX or TOGA indent.
- AFTER TAKE-OFF: Pilot puts Thrust Lever on CLIMB indent.

And now comes the funny part. It stays in climb setting the whole flight until a few seconds before landing! To remind the pilot he need to do something with those levers the aircraft even tells him exactly what to do with the 'retard…retard' call. So the Airbus cruises, descends and lands with the Thrust Lever set in the CLB (Climb) setting.

- AFTER LANDING: Pilot closes Thrust Lever and activates reverse thrust.

So in the air the thrust Levers are used to select the FADEC (the computer that controls the thrust output of the engines) mode and not the amount of thrust they provide.

THOSE PESKY FCU BUTTONS

The buttons on the FCU (the Flight Control Unit, on the glare shield) can be pushed or pulled and this leads to endless confusion for new pilots. Yet there is a great way to remember what is what:

- **PUSH**: you push control from you to the aircraft and go into MANAGED MODE. The aircraft will now fly the route (with altitudes and speed etc) programmed in.
- **PULL**: you pull control from the aircraft to yourself and go into SELECTED MODE. You now have to tell the aircraft what to do.

You'll never be confused again.

LAWS AND PROTECTIONS

Our airbus project is built to be used as 99.9% of all flights are flown. Without serious failures and without the need for the systems to leave NORMAL law mode. However it is good to know about the modes!

There are 5 laws (but each has a ground and flight mode):

1. NORMAL LAW
2. ALTERNATE LAW
3. ALTERNATE LAW (without speed stability)
4. DIRECT LAW
5. MECHANICAL BACK-UP

And you can now forget about that list because when the shit hits the fan and the systems degrade into 'lower' modes even extremely well trained pilots will not know in what modes they are. That's fine as long as you keep flying the aircraft. The laws are there to make sure you get at much help from the systems as possible.

NORMAL LAW

In normal law the aircrafts computers will provide as much protection as possible. When the aircraft threatens to go into an abnormal flight condition (in other words, gets too close the edge of the flight envelope) the systems will try to prevent it. When the aircraft gets into an abnormal flight condition the systems will try to correct it. Here is what it does:

- LOAD FACTOR LIMITATION: prevents high G-loads that are unpleasant for the passengers and potentially dangerous for the airframe. The system will try to stay between +2.5G and -1.0G. A serious rollercoaster will be designed with these same limits in mind btw.
- PITCH ATTITUDE PROTECTION: if there is one thing that your passengers will not like is going steeply up or down (they might be more bothered by the latter and so should you). The system will try to stay between 30° nose up and 15° nose down. At low speed and extended flaps the nose up limitation will lower to 20°)
- HIGH ANGLE OF ATTACK PROTECTION: as we all know your wings will stall when your angle of attack (the angle between the wing and the oncoming air) is too great. That's why the systems will try to prevent the aircraft getting into this situation.
- HIGH SPEED PROTECTION: going too slow is dangerous but going to fast as well. Your Airbus will prevent you from racing other aircraft to the airport.

- BANK ANGLE PROTECTION: another things your passengers will not like is to look out of the window and stare direct at the ground. But also at high bank angles you will lose a lot of lift and speed and G-loads will increase rapidly. That's why the Airbus systems will prevent a very steep bank. It will let you bank up to 67° and when you let go of the stick will return to 33°.

ALPHA FLOOR PROTECTION

A good example (and perhaps the most important) of the protections is the alpha floor protection. It's something every airbus pilot has to demonstrate on check flights and you can do the same. It's safe and its fun.

1. Disengage Auto-Pilot and Auto-Thrust Lever
2. Switch off the Flight Director
3. Retard Thrust Lever and let the speed go down to 'green dot' (the lowest safe speed at that moment).
4. Now imagine an aircraft popping up and you have to avoid hitting it. Initiate a move UP and RIGHT (forcefully!) to avoid a midair collision and observe what happens.

Clearly the aircraft will rapidly run out of airspeed and something needs to happen. Thankfully the Airbus systems will detect this problem and it will initiate the alpha floor protection. The trust will go into TOGA (the maximum available) mode and will stay there until the pilot tells it otherwise. The other protection will prevent you from starting a loop or a roll. Although very close to the edge of the flight envelope the aircraft will stay controllable during the whole procedure!

Oh, you want to know how to get back to stabilized flight?

1. Push forwards on the stick to reduce the angle of attack
2. Level the wings and let the aircraft 'fly out of' the problem. But you are about to face a new problem as speed will increase rapidly and you could go from too slow to too fast in seconds!
3. Disengage Auto-thrust again by pushing the side button on the Thrust lever.
4. Select a safe speed on the FCU (for example 250 Knots).
5. Select both Flight Directors on again.
6. Re-engage Auto-thrust with the FCU A/THR button.
7. Set Thrust lever in CLIMB detent.
8. Re-engage Auto-pilot and establish normal flight.
9. Might not be a bad idea to talk to the passengers and to tell the cabin crew to distribute drinks for the adults and toys for the kids.

PHASES

In Airbus logic every flight is divided into stages and stages are very important to understand the logic of the Airbus systems. Consider a stage to be a combination of system settings and parameters. There are 8 phases:

- PREFLIGHT
- TAKE_OFF
- CLIMB (CLB)
- CRUISE (CRZ)
- DESCENT (DES)

- APPROACH (APPR)
- LANDING
- GO AROUND

In a flight, even a very short one, all these stages will follow each other (or course expect the Go Around). **When this chain of phase is not completed some of the automation of the aircraft systems will not be available!**

PHASE TRIGGERS

A phase trigger switches one phase into the next phase. These triggers (events) can be complex but can be simplified like this:

- PREFLIGHT
  - Thrust levers to FLX or TOGA
- TAKE_OFF
  - Reaching ACCEL altitude that was set in the MCDU PERF page
- CLIMB (CLB)
  - Reaching cruise altitude that was set in the MCDU PERF page
- CRUISE (CRZ)
  - **Manual** activation of descent and leaving cruise altitude (keep in mind that in most settings the Airbus will not start to descent without pilot interaction!)
- DESCENT (DES)
  - Manually activate and confirm APPR in the MCDU PERF page
- APPROACH to LANDING
  - Touchdown or Autopilot disconnected
- APPPROACH to DONE
  - 30 seconds after landing and INIT or PERF pb is pressed

Alternative from APPROACH to LANDING:

- APPROACH to GO AROUND
  - Thrust Levers to TOGA while in APPROACH phase

MODES

Next to phases you got to understand Modes. They are not as complex as Phases as there are only three (I copied this from airbusdrivers.net, a great resource for any Airbus enthusiast) but as they change the way controls work they are important.

- Ground Mode
  - Active when aircraft is on the ground.
  - Direct proportional relationship between sidestick deflection and flight control movement
  - Direct proportional relationship between the Thrust Lever levers control setting and thrust.
  - Is active until shortly after liftoff.
  - At touchdown, ground mode is reactivated and resets the stabilizer trim to zero.
- Flight Mode
  - Active shortly after takeoff and remains active until shortly before touchdown.

- Sidestick deflection and load factor imposed on the aircraft are directly proportional, regardless of airspeed.
- With sidestick neutral and wings level, system maintains a 1 g load in pitch.
- No requirement to change pitch trim for changes in airspeed, configuration, or bank up to 33 degrees.
- At full aft/fwd sidestick deflection system maintains maximum load factor for flap position.
- Sidestick roll input commands a roll rate request.
- Roll rate is independent of airspeed.
- A given sidestick deflection always results in the same roll rate response.
- Turn coordination and yaw damping are computed by the ELACs and transmitted to the FACs.
- No rudder pedal feedback for the yaw damping and turn coordination functions.

- Flare Mode
  - Transition to flare mode occurs at 50' RA during landing.
  - System memorizes pitch attitude at 50' and begins to progressively reduce pitch, forcing pilot to flare the aircraft
  - In the event of a go-around, transition to flight mode occurs again at 50' RA.

MINIMUM GROUND SPEED

Minimum Ground Speed (or MINI GS) is rather clever system that protects the aircraft from the dangers of microburst related windshear. A microburst is a downwards moving pocket of air that can be highly dangerous to aircraft on approach. Not only because it will ‘push’ the aircraft down but even more because the aircraft can get in a sudden tail wind situation that will reduce list or cause a sudden and unexpected stalls.

MINI GS functions by increasing the Final Operating Airspeed thus enhancing the protection against stall. The increase in based on the wind speed (taken from ATIS) inserted by the crew in the MAG WIND item of the PERF/APPR page and will only function in MANAGED speed mode.

On the Professional Pilots Rumour Network it was explained by Chris Scott like this: “*GS-MINI is, as the name implies, based on a minimum ground speed. Before the approach, once the crew can predict with reasonable confidence what the surface-wind is likely to be at the landing threshold, they enter the figure into the approach Performance page. The FMS works out the correct Vapp, which is a threshold IAS based on weight and headwind component.*

Now: let's take the sea-level ISA case, where IAS=TAS; a Vapp of 130kts; and a predicted headwind of 10kts entered into the Performance page. On a conventional airplane stabilised at Vapp (130kts) at a height of 500ft, if the headwind is 30 kts the GS will be 100kts. But when it comes over the threshold, where the headwind is only 10kts, it will need to have accelerated to a GS of 120kts to maintain the required Vapp of 130. This will require a lot of extra energy (from the engines), which may cause problems, particularly if the loss of headwind happens suddenly (like at night).

It makes sense, therefore, to ensure that the GS remains at or above 120kts throughout the approach, even though this initially results in a higher IAS (150kts at 500ft in this case). The "managed" speed (IAS) target on the ASI (used by the pilot and the autot hrottle) goes up and down with the headwind, but never below Vapp. Reaching the threshold, provided the actual headwind equals the predicted figure, the speed target *will be Vapp. If the wind is higher, the speed target will be above Vapp. This should not be a problem for stopping in the runway length, because the GS will be no higher than originally planned.*

In practice? Works very well, particularly using manual Thrust Lever, provided the pilot uses the "managed" speed as a target speed; not a minimum speed. The power changes required in windshear are far less than on a conventional aeroplane, because the GS (kinetic energy) is steady."

Using MINI GS is not without drawbacks. You might see that your managed speed (and thus ground speed) fluctuates and in a busy environment this could cause problem in the traffic flows.

SPEED REFERENCE SYSTEM

The Speed Reference System (SRS) will guide the aircraft along the vertical path during the take-off phase (and go around stage). It prevents the aircraft from climbing too steep and loosing airspeed.

It is armed when V2 in entered on the PERF page of the MCDU and flaps/slats not fully retracted.

It is triggered by the thrust levers placed in the take-off position and will control pitch after rotation and it will maintain an airspeed between V2+10 knots and V2+15 knots and at minimum a 120 FPM climb. When vertical speed drops below 120 FPM the system allows the speed to decrease to V2.

FLAPS 1

Another fine example of Airbus logic. If you move the flaps lever from 0 to 1 airborne, the flaps will not move! Only the slat (at the front of the wing) will deploy. Of course that would be too easy so on the ground flaps 1 WILL extend the flaps and when you retract them from 2 to 1 they will stay out. Don't even try to get your head around this, accept that the engineers thought about this and that it is best for the aircraft.