Podcast 28 – Flight controls Part 2

Hi everyone and welcome back to the sequel of our exciting 2 parter on the 737 talk. We'll continue the subject with a look at Yaw control, speed brakes and flaps and slats with their various protections. Given the level of detail over these last two podcasts I think we'll aim for a slightly less technical subject next time, perhaps another look at a non-normal.

Let's get into the technical side for now though and start with Yaw control. On our 737 we have a hydraulically powered rudder as well a digital yaw damper system. We control the rudder inputs through our bus rod, captain and first officer, interconnected rudder pedals whereas the SMYDs, stall management and yaw damper computers, control the yaw damping functions.

Just a mention of those FLT CONTROL switches again here. As per the ailerons and elevators these can isolate the respective system but in the case of the rudder also allow the standby PCU to receive hydraulic pressure.

Each set of rudder pedals is mechanically connected to the input levers of the main and standby rudder PCU's. The main PCU consists of 2 independent input rods, 2 individual control valves, and 2 separate actuators: one for Hydraulic system A and the other for B.

The standby system has a separate input rod and control valve powered by that system. All three rods have individual jam override mechanisms which allow input commands to continue to be affective from the remaining free rods.

Our rudder pedals give us 7° a side of nose gear steering with the rudder becoming aerodynamically effective at speeds between 40-60kts. At speeds above 135kts both Hydraulic systems A and B pressure is reduced by 25% to limit rudder authority after takeoff and before landing.

Now to define the FFM or Flight Force Monitor. The FFM is contained in the main rudder PCU along with the yaw damper and the load limiter we just discussed. It detects opposing pressure, or a fight, between actuators A and B. This may occur in the event of a system jam or disconnect. The FFM output will automatically turn on the standby hydraulic pump, open the standby rudder shutoff valve pressurising the standby rudder PCU and will alert us to this fact by illuminating the Master Caution, STBY RUD ON and FLT CONT annunciator lights.

The STBY RUD ON light illuminates when the standby rudder hydraulic system is pressurised. This can be done by selection of either Flight Control switch, automatically during takeoff or landing which for the conditions please refer to the Hydraulics podcast, or automatically by the FFM.

To trim the rudder, we have the rudder trim control located on the aft electronic panel. This electrically repositions the rudder feel and centring unit, yes, we have one of these for the rudder too, so it didn't feel left out from the ailerons and elevator, thus adjusting the rudder neutral position. This system is powered through Transfer bus 2 and proportionately displaces the rudder pedals. Our rudder trim indicator displays to us the position in units.

To provide dutch roll prevention, gust damping and turn coordination we have a main and standby yaw damper. Both are controlled through the SMYDs who receive inputs from the ADIRUs, both control wheels and the yaw damper switch. The SMYDs then pass their information to the main rudder PCU or standby rudder PCU.

In normal operation SMYD1 passes its information to the main rudder PCU and hydraulic system B pressure is then used to move the yaw damper actuator.

In manual reversion the standby yaw damper uses the standby rudder PCU and standby hydraulic pressure with the inputs coming from SMYD 2. During manual reversion our Wheel to rudder interconnect system or WTRIS supports standby rudder operation through SMYD 2 which receives one of its input signals from the captains control wheel allowing coordinated turns during manual reversion.

To enable this both FLT CONTROL switches must be in STBY RUD and the Yaw damper switch turned ON as is directed in the manual reversion QRH.

In the case of a loss of system B you would notice that the yaw damper switch does not initially kick off, however primary yaw damping is indeed lost. Once you get in to the QRH and select FLT CONTROL B switch to STBY RUD the switch will then go to the OFF position. As a purely technical point of interest, to regain yaw damping function you would have to revert to manual reversion but I think we'd all prefer to live without the yaw damper than purposely depressurise our other main hydraulic system!

Other reasons our yaw damper switch may kick off could be either the SMYD sensing a yaw damper system fault or the SMYD sensing the yaw damper not responding to a command.

We briefly discussed flight spoilers in the first part but let's go into a bit more detail on the whole speed brake system. We have 4 ground spoilers, all powered by hydraulic system A and 8 flight spoilers utilising the A and B hydraulic systems. The speed brake lever controls the spoilers deploying them all on the ground and only the flight spoilers in flight.

The SPEEDBRAKES EXTENDED light will illuminate inflight to warn us the speed brakes are extended below 800 feet RA or, on the ground when hydraulic pressure is sensed in the ground spoiler shutoff valve with the speed brake lever down.

We also have a SPD BRK DO NOT ARM light which illuminates for an abnormal condition or if the wheel speed has dropped below 60kts on landing and the speed brake is not in the down position.

When using the spoilers in flight we should be cautious operating them in a turn as they greatly increase roll rate. Any movement beyond the FLIGHT DETENT in flight will cause buffeting and is prohibited with some 737's having a lever stop feature that will prevent inflight movement beyond FLIGHT DETENT.

For ground operations the auto speed brakes will deploy when:

- Speed brake lever is armed

- Speed brake armed light is illuminated
- Rad alt is less than 10ft
- Landing gear strut compresses on touchdown, either strut for flight spoilers, right main strut for ground spoilers
- Both thrust levers at IDLE
- Main landing gear wheel spin up > 60kts

If the speed brake lever was left in the down position during landing or a rejected take off the automatic system will still operate if; wheel spin up greater than 60kts is detected, both thrust levers are idle and reverse thrust is selected.

After an RTO or landing, if either thrust lever is advanced, the speed brake lever automatically returns to DOWN and all spoiler panels are retracted.

We'll finish the subject with a fairly meaty section on the high lift devices and their back-ups and protections. On the leading edge we have four flaps and eight slats, two flaps inboard and four slats outboard of each engine. The LE Kruger flaps have one extended position whilst the slats extend to form a sealed, extended, or slotted, fully extended, leading edge depending on the TE Flap position.

For SFP aircraft the slats go to FULL EXT past flap 25 whilst NON SFP see FULL EXT past flap 5.

The TE devices consist of double slotted flaps inboard and outboard of each engine. Positions 1-15 provide increased lift with positions 15-40 providing increased lift and drag. Flaps 30 and 40 are our normal landing positions.

The limitation of max altitude for deployment of the flaps of 20,000ft is there to prevent excessive structural loads from increased Mach at higher altitudes.

Extension and retraction of both LE and TE is normally powered by hydraulic system B pressure. Positioning the flap lever moves cables that are attached to the flap control unit. This then directs hydraulic B pressure to power the flap power drive unit. The flap power drive unit then turns the torque tubes which transmit the power to 8 TE flap transmissions thus moving the actual surface.

LE deployment is sequenced in regard to TE position. As previously mentioned, the sequencing is slightly different depending on if you're in a Short Field Performance 737 or not. TE always move to the lever commanded position whereas LE will move as follows. For all types the LE Kruger flaps will move to their only position of full extend once the flap lever is moved to position 1. Again in both types at this point the LE slats will move to their first position of Extend. On the NON SFP the LE slats will go to full extend from lever position 10 onwards whereas on the SFP this is delayed until position 30. The sequence is reversed for retraction.

On the aft overhead we have our leading-edge devices annunciator panel that allows you to monitor position of the individual flaps and slats and whether the devices are in transit. You also have the LE FLAPS TRANSIT light which will illuminate when:

- Any LE device is in transit
- Any LE device is not in the programmed position with respect to the TE flaps
- A LE uncommanded motion exists, which is 2 or more LE flaps or slats have moved away from their commanded position.
- And, during alternate flap extension it will illuminate until LE devices are fully extended and TE flaps reach flap 10, or 15 on SFP

A quick reminder why those mechanical gates are in place at positions 1 and 15 on the flap lever. It is all about the go-around. They are there to stop inadvertent selection past the stage of flap required which in the event of a two engine go around is 15 and for a single engine go around flap 1.

We have a flap load relief system of the 737 which will retract the TE flaps when exceeding placard speeds to protect against structural damage. It is a function of the FCEU or Flap Slat Electronic Unit and again we have some differences between the SFP and NON SFP models. For NON SFP models it is active for flap settings 30 and 40 whereas for SFP models for flaps 10 through 40. We won't go through all the speeds but let's look at our two normal landing flap positions as an example.

Flap 30 will retract to flap 25 when speed reaches 176kts and will reextend when speed reduces to 171kts.

Flap 40 will retract to flap 30 when speed reaches 163kts and will reextend once speed reduces to 158kts.

The FSEU receives air data from the left ADIRU as well as data from the TE position transmittors, TE skew sensors and LE sensors. The FSEU commands the LE device annunciator and the flap position indicator as well as the associated lights. The FSEU not only provides load relief but also asymmetry and skew protection which Mark is now itching to tell you about, or perhaps he's just having a reaction to having to do so much work.

Nope it's definitely my love of flap protection systems that's causing it. So, what is asymmetry and skew? Firstly, if a device on one wing doesn't align with its associated device on the other then we have asymmetry. Skew, however, occurs when otherwise symmetrical TE flaps do not operate at the same rate causing the panels to twist during extension or retraction. Should a skew occur the FSEU automatically protects against roll by maintaining flap symmetry. These protections are not available when using the Alternate flaps.

When the FSEU detects a TE asymmetry or skew condition it closes the TE flap bypass valve, displays a needle split on the flap position indicator and shows the position of the left and right trailing edge flaps.

When the FSEU detects a LE device in an improper position the LE FLAPS TRANSIT light remains illuminated.

Both skew and asymmetry have the same QRH of "Trailing Edge Flap Asymmetry" but a method of diagnosing whether you have skew or asymmetry is how the needles are split on the flap position indicator. If the needles are pointing to precise numbers i.e., the left says 5 and the right says 10 then you have asymmetry. If one needle is pointing to somewhere between your normal flap positions, say 7 or 8° then you have skew.

Before wrapping up this topic with a look at autoslats and the alternate system we'll have a quick chat about uncommanded flap and slat motion.

This is yet another function of our trusty FSEU. In regard to the leading edge. If uncommanded motion is detected and two LE flaps move on one wing or two or more slats move on one wing the FSEU shuts down LE control and illuminates the LE FLAPS TRANSIT light.

In addition to this, to prevent uncommanded motion during the cruise the FSEU maintains pressure on the retract lines and depressurises the extend and full extend lines.

As for the trailing-edge. If flaps move away from the commanded position or continue to move after reaching the commanded position or move in a direction opposite to that commanded, then the FSEU will shut down the TE drive unit by closing the TE flap bypass valve. This shut down cannot be reset by us and we must use the alternate flap system to control TE flaps as directed by the trailing edge flap disagree QRH. The shutdown is indicated by the flap position indicator needles disagreeing with the flap lever position, there is no split.

We have mentioned Autoslats before and their role during approach to stall. As a bit more of a background they are normally powered through Hydraulic system B but do have an alternate source of power through system A powering the PTU if a loss of pressure is sensed from the higher volume system B engine driven pump such as would happen in an engine number 2 failure for example. For more information on the PTU please refer to episode 7, hydraulics.

On a NON SFP aircraft the autoslats are available when trailing edge slats are 1 through 5 or on an SFP aircraft when the flaps are 1 through 25. On approach to the stall when in these flap settings the leading-edge slats will be driven to full extend thus enhancing the 737 stall characteristics.

And finally, a quick look at the alternate extension. In the event of Hydraulic B system loss, an alternate mode of extending the LE devices and extending and retracting the TE flaps is provided.

For the TE this means an electrically operated system actuated by the two alternate flap switches. The guarded Alternate flaps master switch first closes a flap bypass valve to prevent hydraulic lock of the flap drive unit, as well as energising the standby pump needed for LE movement, and also arms the alternate flaps position switch.

This alternate flap position switch then controls an electric motor that extends or retracts the flaps with certain operating limitations attached. The switch must be held in the DOWN or UP position until the desired flap position is reached as shown on the flap position indicator.

Once released this switch shouldn't be moved again for 15 seconds to avoid damage to the alternate flap motor clutch. After a complete cycle 0-15-0 allow 5 minutes of cooling before another attempt. Just to reenforce here, we have no asymmetry or skew protection which is why you see the line "as flaps are extending, slow to respective manoeuvring speed" allowing you to carefully monitor that flap position indicator for correct movement. You'll also observe another system limitation of a maximum speed during extension of 230kts.

When using alternate flaps, the leading edge is driven to full extend as soon as you hold the switch in the down position. The LE extension is powered by the standby hydraulic system, but they cannot be retracted which is something to bear in mind before committing to an approach. The overall time to extend the flaps using the alternate system is significantly longer than with the normal system and this again needs to be considered. When we timed this in the simulator it took 1minute and 38 seconds to run from up to flap 15 so there's a ballpark figure for you but times will of course vary on the real aircraft on the day.

So, that's it, a mammoth topic covered with plenty to think about and if any questions come up, please either contact us directly through the b737talk.com website where you'll also find the answers to the following…

Talks Tech Ten

Q1: Why, at speeds above 135kts is hydraulic system pressure reduced by approximately 25% to the main PCU?

Q2: Which hydraulic system powers the ground spoilers?

Q3: Will the spoiler panels extend on landing if you leave the lever in the DOWN detent? If so, when?

Q4: Flap extension should not be attempted above what altitude?

Q5: When the flap lever is moved from UP to 1 what happens to the leading edge.

Q6: When in flap 30 the trailing edge will auto retract to flap 25 at what speed? Then at what speed will it re-extend to 30?

Q7: What effect does the autoslat system have on slat position when it operates?

Q8: Which hydraulic system powers the leading edge when using alternate flaps and are there any considerations on that leading edge to be aware of?

Q9: What effect does an upslope have on V1 speed?

Q10: After a rapid decompression at 35,000ft what is the sedentary TUC for a reasonably fit individual?

That’s it for this episode, we hope you’re enjoying the new feature and we’ll continue to test the brain cells after each episode. If you want to continue the Talk head over to any of our social media where you’ll find us @b737talk or you can join the LinkedIn group b737training.org. Feel free to contact us directly through the website where you can also sign up to the newsletter for info on the podcast ahead of the rest. From Mark and I though, until next time fly well and be safe.