Even as the recertification efforts of the B737 max are on full swing, there is an increasing concern and demand for training. The content of the training is yet to decided but there is also a need to look at the history of Boeing accidents. There has been a certain pattern to the way the ill-fated aircrafts have ended up with. An irrecoverable steep dive at high speed.

Airline	Place of accident	Pitch down	Trim/Thrust	Speed
Ethiopian	Beirut	63 deg	Nose DN/High	407 kts
Lion Air	Jakarta	45 deg	Nose DN/High	450kts
Tatarstan	Kazan	75deg	Nose DN/High	391kts
Ethiopian	Addis Ababa	45deg	Nose DN/High	458kts
Fly Dubai	Rostov	50deg	Nose DN/High	340kts

B-737 accidents

How to trim the Stabilizer

While the blog need not explain the functioning of the Horizontal Stabilizer (STAB), there is an important correlation between the way the accidents have ended up and the role of the STAB in inserting the final nail in the coffin.

The B737 FCTM explains the procedure for trimming the rudder in detail but does not provide information on how to trim the STAB. The difference between trimming the rudder and the STAB is that:

To trim the Rudder, the surface has to be deflected and trimmed so that the surface stays in

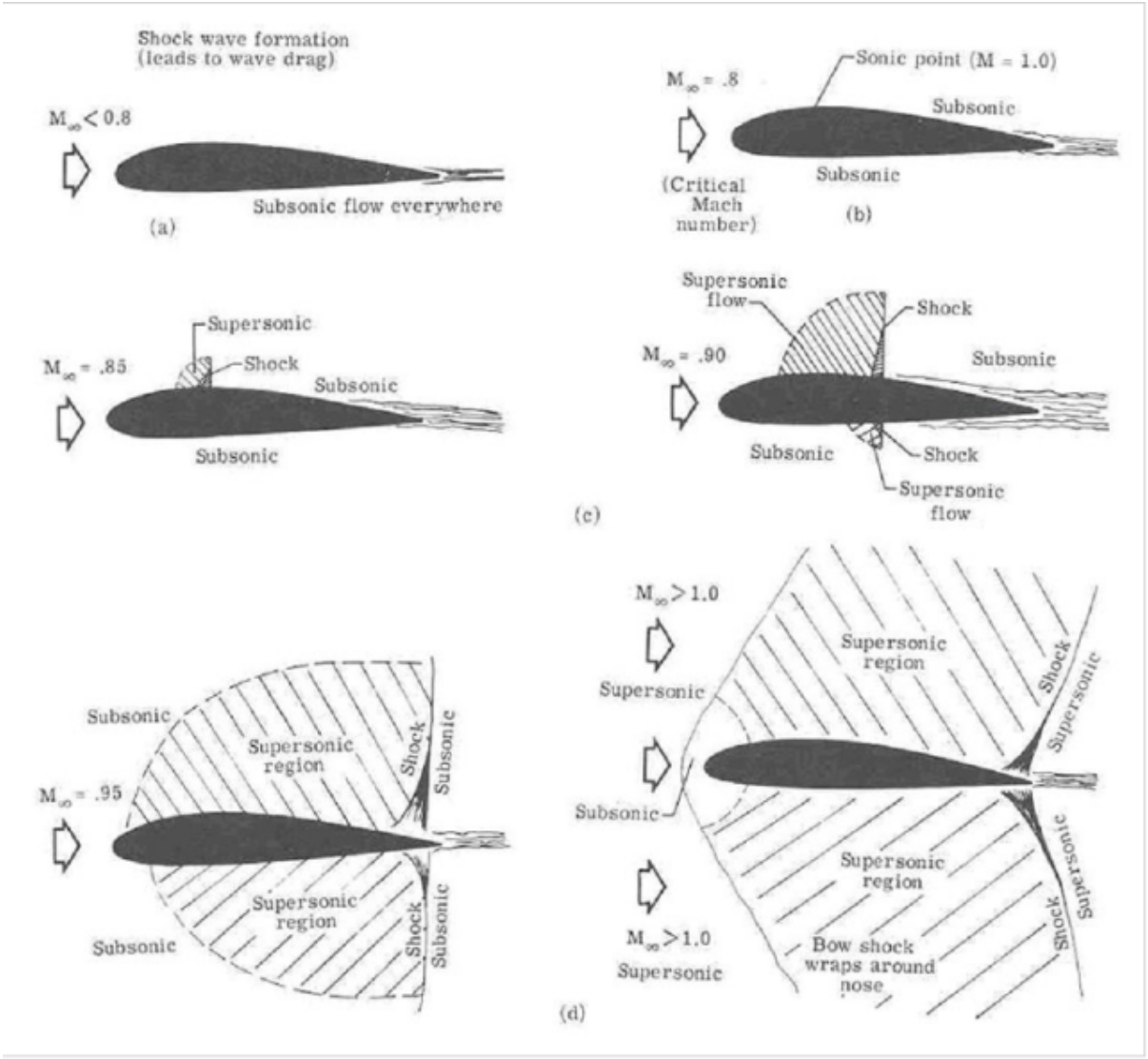
the new position. This creates aerodynamic forces which counters the effect which caused the upset.
On the contrary, the horizontal surface of the tailplane is split into the larger portion of the STAB and the smaller elevator. The STAB is trimmed for keeping the elevator on a NEUTRAL position.

B737 FCTM extract

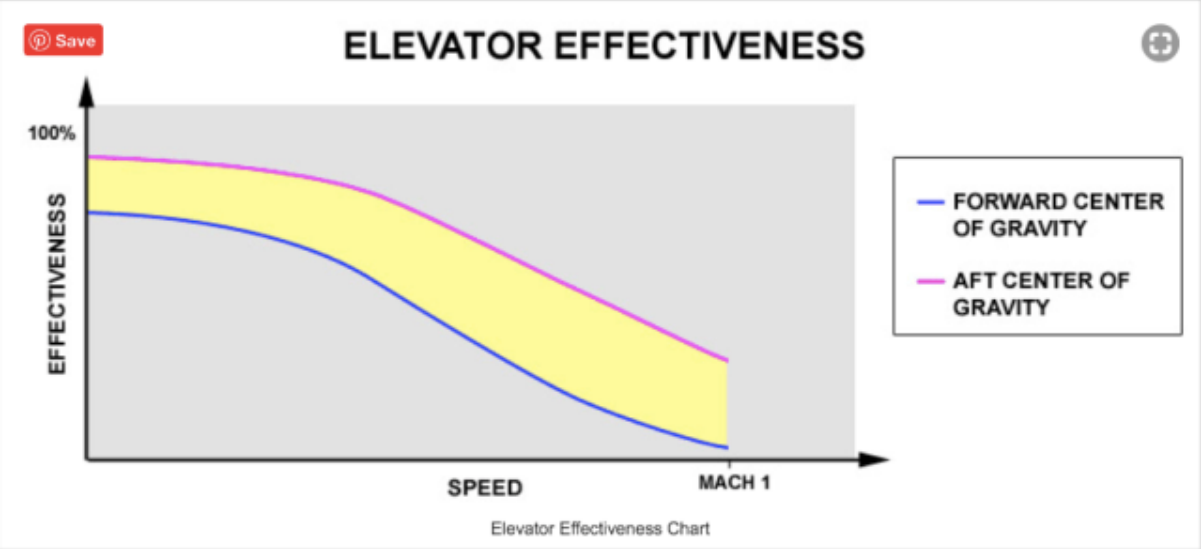
Tail plane stall

A tailplane is the surface that maintains the balance of the aircraft. The horizontal surface creates an inverted aerofoil and creates an up or downward force which balances the pitch movement of the nose up or down. The Northwest flight 705, a Boeing 720 crashed in 1963. The reason of the crash was attributed to the tailplane stalling due to the surface Shock waves developing on the stabilizer near cruise Mach numbers. The resulting disturbance to the air behind the shock waves causes the elevator to lose some of its effectiveness.
The movement of the horizontal stabilizer to full nose down either by the crew input or by erroneous activation of the MCAS causes aerodynamic forces which cannot be physically overcome. The elevator is rendered ineffective once the airflow over the tailplane exceeds high mach number. The STAB motor is unable to move when the elevator too is moved to attain a full nose up position.

The only way out is to ease the the elevator to neutral and use only the stabilizer trim to a nose up position.



Shockwave formation



Elevator effectiveness

At speeds below the transonic region, air flows smoothly around the airplane. In the transonic region, airflow begins to reach the speed of sound in localized areas on the aircraft, including the upper surface of the wing. The Airplane Mach number at which airflow over the wing first reaches Mach 1 is known as the critical Mach number.

Air flows more rapidly over the upper surface of the wing, resulting in a lower pressure than on the lower surface. This pressure differential between the two surfaces is what creates lift. At jet transport cruising speeds (typically Mach 0.80 – 0.85), the airflow over the upper surface of the wing becomes supersonic. As the local airflow over the wing becomes increasingly supersonic, shock waves form and increase in strength and extent. Shock waves are formed by a large pressure gradient that results from the formation of supersonic flow regions on the wing. As air moves through the shock wave, it suddenly decelerates to become subsonic. The shock wave is the location where this transition occurs.

Watch the Northwest 705 accident animation for better understanding.

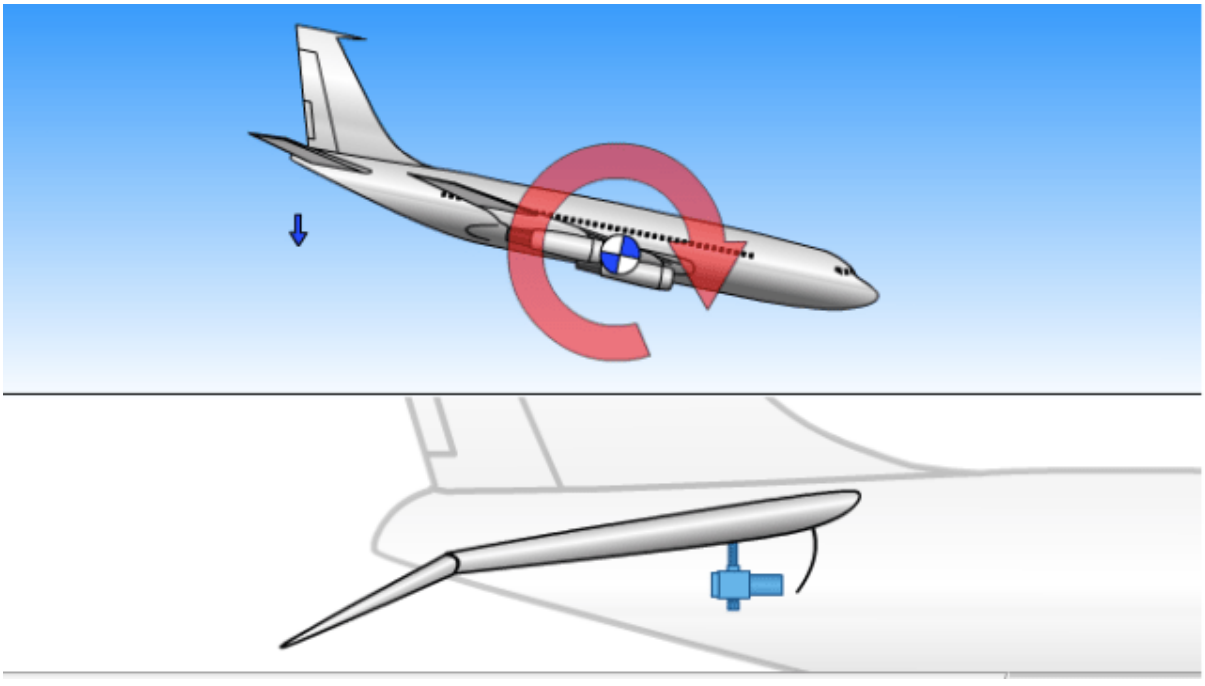
Northwest 705 animation. Courtesy Joshua Freund for providing the link.

mindFly analysis

The pilots have to be trained on the use of STAB trim. Unlike the smaller aircrafts on which the basic flying training takes place in the flying schools, the bigger jets have some fundamental differences that not all the pilots are trained for.

The smaller aircrafts do not have a STAB and fly at slow speeds. Therefore the elevator has a trim tab. On these aircrafts the elevator is held to a deflected position to balance the nose and the trim tab moved till the force on the control wheel that the pilot holds feels light. The elevator is trimmed out of the neutral position to balance the aircraft.

On bigger aircrafts which have a STAB and an elevator, an elevator in a deflected position will create a bigger drag and will be inefficient. Therefore on these aircrafts the STAB is moved UP or DN in order to trim the elevator to a NEUTRAL position.



A nose DN trim with Forward elevator

In the accidents, there was a pitch up movement which led to the pilot moving the STAB full down and the Elevator full forward. The resultant action put the aircraft into a nose dive and the airspeed increased beyond the VMO/MMO. In the MCAS related accidents, the MCAS moved the STAB down.

How to trim

If the elevator is deflected DN to counter for a nose UP and the STAB is trimmed for nose DN the resultant effect is inadequate since the moment the force on the elevator is released, the elevator returns to Neutral position. therefore the pilot again pushes the nose down and trims even more nose DN. This results in excessive nose DN which cannot be physically countered by human force.

The pilot needs to use the elevator to initiate pitch movement or arrest movement, thereafter use the trim alone to achieve the balance. If the aircrafts ends up in an upset as described in teh blog above, the way out is to ease the elevator to help it return to neutral position, this will reduce aerodynamic forces which were locking the STAB motor and thereafter use only the STAB to recover the nose to a level flight.

Boeing must include training the pilots on this aspect of jet upset and recovery.

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