Podcast 42, RVSM

Hello everyone, and welcome to another episode of the 737 Talk, where we try to help with aircraft & procedural technical refreshers, discussing together incidents involving the 737, from which we can all learn. We thought today we'd have a brief discussion on RVSM airspace the history behind it, and generic principles and procedures associated with it. Most of us will fly within RVSM airspace around Europe and North America, and there are some specific pre-requisites to use it, and we'll discuss what they are and why.

The introduction of RVSM permits the application of a 1000 ft vertical separation minimum (VSM) between suitably equipped aircraft in the level band FL290-FL410 inclusive, thereby making available six additional usable flight levels. The purpose of the implementation of RVSM was to increase capacity, through the provision of these six additional flight levels, to reduce controller workload, while maintaining or improving upon, current levels of safety and to provide the airspace user community with an improved operating environment for optimising flight profiles.

The making available of these additional levels is one of the means which will enable controllers:

- to efficiently handle both the current and future levels of traffic within their areas of responsibility, increasing ATC capacity,
- to de-conflict strategically traffic over the major crossing points of the European ATS route network more effectively, and
- to accommodate pilot requests for optimal cruising levels giving optimum route profiles.

A brief History.

In the late 1950s it was recognised that, because of the reduction in accuracy of pressure-sensing of barometric altimeters with increasing altitude, there was a need above a certain flight level to increase the prescribed vertical separation minimum (VSM) of 1000ft. In 1960, an increased VSM of 2000ft was established for use between aircraft operating above FL 290 except where, on the basis of regional air navigation agreement, a lower flight level was prescribed for the increase. The selection of FL 290 was not so much an empirically based decision, but rather a function of the operational ceiling of aircraft at that time. In 1966, this change-over level was established at FL 290 on a global basis. At the same time, it was considered that the application of a reduced VSM above FL290, on a regional basis and in carefully prescribed circumstances, was a distinct possibility in the not-too-distant future. Accordingly, ICAO provisions stated that such a reduced VSM could be applied under specified conditions within designated portions of airspace on the basis of regional air navigation agreements.

In the late 1970s, so Mark tells me anyway…. faced with rising fuel costs and growing demands for a more efficient utilisation of the available airspace, ICAO initiated a comprehensive programme of studies to examine the feasibility of reducing the 2000ft VSM applied above FL 290, to the same 1000ft VSM which is applied below FL290. Throughout the 1980s, various

studies were conducted, under the auspices of ICAO in Europe, Canada, Japan, and the United States.

The results of these exhaustive studies demonstrated that the reduction of vertical separation was safe, cost beneficial and feasible - without the imposition of unduly demanding technical requirements.

The studies also showed that the types of aircraft and the essentially unidirectional flow of traffic in the North Atlantic Minimum Navigation Performance Specifications (MNPS) airspace, made the NAT Region an ideal candidate for the first implementation of RVSM, and so planning for RVSM in the NAT Region commenced in 1990. The first stage of the Operational Evaluation phase, using the 1 000 ft RVSM, began on the 27th of March 1997 in the level band FL 330 to FL 370 inclusive. The application of RVSM was extended in a second stage to encompass FL 310, FL 320, FL 380 and FL 390 in October 1998. From the outset it was clear that the complex nature of the European ATS route structure, the wide variety of aircraft types, high traffic density and the high percentage of climbing and descending aircraft, would be a more complex ATM environment than the North Atlantic Region for the implementation of RVSM.

Thus, safety considerations were given a high priority in the initial ECAC RVSM feasibility studies which were conducted under the auspices of the EUROCONTROL Airspace and Navigation Team (ANT). These studies indicated that, subject to aircraft meeting the altimetry MASPS, or Minimum Aircraft Systems Performance Specifications, RVSM could be introduced into the European Region without compromising required safety levels, and also that it would provide a positive benefit to cost ratio over a wide range of assumptions regarding future developments within the European aviation environment.

Between 1997 and 2005 RVSM was implemented in all of Europe, North Africa, Southeast Asia and North America, South America and over the North Atlantic, South Atlantic and Pacific Oceans. The entire western hemisphere implemented RVSM FL 290–FL 410 on 20th January 2005. Africa implemented it on 25th September 2008. The People's Republic of China implemented metric RVSM on 21st November 2007. The Russian Federation implemented RVSM and flight levels in feet on 17th November 2011.

The Importance of Perception:

Understanding perception is important for pilots: perception is the stage of Information processing prior to decision making and judgment, from which actions are taken. Effective decision making and safe actions rely on accurate perception.

Therefore, it is important that pilots also know how to overcome the two misperceptions introduced above - limitations and subjectivity. In simple terms they can do this by deferring to reliable data. In the first case this is provided by appropriate flight instruments and in the second case other objective sources of data (other crewmembers, ATC, manuals, checklists and documents). However, the pilot will have to counter his/her intuitive feelings: when a pilot believes that their aircraft is in a certain attitude, or position and power state, then his/her mind will try to organize whatever information is available to confirm this belief.

On a clear night, distant stationary lights can be mistaken for stars or other aircraft. Even the northern lights can confuse a pilot and indicate a false horizon, which in turn may cause problems of visual perception of other aircraft at 300 m (1 000 ft) planned separation for opposite and same direction traffic, and during turns.

RVSM Operations:

According to EASA regulation SPA.RVSM.100, the aircraft shall only be operated in designated airspace where a reduced vertical separation minimum of 300 m (1 000 ft) applies between flight level FL 290 and FL 410, inclusive, if the operator has been granted an approval by the competent authority to conduct such operations. Authorisation for VFR flights to operate above FL 290 shall not be granted in areas where a vertical separation minimum of 300m (1000ft) is applied above FL 290 (RVSM airspace).

Equipment/functions required to begin RVSM operations are listed in the Airplane Flight Manual and FCOM. The MEL includes these requirements.

(GM1 SPA.RVSM.105(d)(9) RVSM operational approval):

- The areas of applicability (by Flight Information Region) of RVSM airspace in identified ICAO regions is contained in the relevant sections of ICAO Document 7030/4. In addition, these sections contain operating and contingency procedures unique to the regional airspace concerned, specific flight planning requirements and the approval requirements for aircraft in the designated region.
- Comprehensive guidance on operational matters for European RVSM airspace is contained in EUROCONTROL Document ASM ET1.ST.5000 entitled “The ATC Manual for a Reduced Vertical Separation (RVSM) in Europe” with further material included in the relevant State aeronautical publications.

Now, according to SPA.RVSM.110 airplanes should be certified to participate in RVSM operations and be equipped with two independent altitude measurement systems that should be made up of the following components:

- cross-coupled static source/system, with ice protection if located in areas subject to ice accretion.
- equipment for measuring static pressure sensed by the static source, converting it to pressure altitude and displaying the pressure altitude to the flight crew,
- equipment for providing a digitally encoded signal corresponding to the displayed pressure altitude, for automatic altitude reporting purposes, and
- static source error correction (SSEC), if needed to meet the performance criteria for RVSM flight envelopes,

Other equipment requirements include:

- Signals referenced to a flight crew selected altitude for automatic control and alerting. These signals will need to be derived from an altitude measurement system meeting the performance criteria for RVSM flight envelopes.
- an automatic altitude control system;
- a secondary surveillance radar (SSR) transponder with altitude reporting system that can be connected to the altitude measurement system in use for altitude control.

During flight planning the flight crew should pay particular attention to conditions that may affect operation in RVSM airspace. These include but may not be limited to verifying that the airframe is approved for RVSM operations. Other factors to check include:

- reported and forecast weather on the route of flight, something like severe turbulence for example may affect the ability to maintain aircraft altitude.
- minimum equipment requirements pertaining to height-keeping and alerting systems; and any airframe or operating restriction related to RVSM operations. You'll need to refer to your company approved MEL or FCOM for any defects effecting RVSM capability.

A good example on the 737 is the requirement for two Air Data reference functions of the ADIRUs so that both altimeters aren't feeding off the same source, which wouldn't meet those RVSM MASPS requirements for two independent primary altimetry systems.

There are Procedures required Prior to entering RVSM airspace, and these will be similar to that we will discuss now. But your company or operator will have their own specific procedures which will need following :

- There needs to be two primary altitude measurement systems. A cross-check between the primary altimeters should be made. A minimum of two will need to agree within ±60 m (±200 FT). Failure to meet this condition will require that the altimetry system be reported as defective and air traffic control (ATC) notified;
- One automatic altitude-control system;
- One altitude-alerting device; and an
- Operating transponder.

Note: Should any of the required equipment fail prior to the aircraft entering RVSM airspace, the pilot should request a new clearance to avoid entering this airspace.

Once in RVSM airspace, again there are procedures that your operator will have published for you to follow to ensure compliance with the rules:

- Flight crew should comply with any aircraft operating restrictions, if required for the specific aircraft type, e.g. limits on indicated Mach number, given in the RVSM airworthiness approval
- In level cruise it is essential that the aircraft is flown at the cleared flight level. This requires that particular care is taken to ensure that ATC clearances are fully understood and followed.

- The aircraft should not intentionally depart from cleared flight level without a positive clearance from ATC unless the crew are conducting contingency or emergency manoeuvres.
- When changing levels, the aircraft should not be allowed to overshoot or undershoot the cleared flight level by more than 45 m (150 FT). If installed, the level off should be accomplished using the altitude capture feature of the automatic altitude-control system.
- An automatic altitude-control system should be operative and engaged during level cruise, except when circumstances such as the need to re-trim the aircraft or turbulence require disengagement. In any event, adherence to cruise altitude should be done by reference to one of the two primary altimeters. Following loss of the automatic height-keeping function, any consequential restrictions will need to be observed.

Ensure that the altitude-alerting system is operative.

At intervals of approximately 1 hour (check your specific company procedure), cross-checks between the primary altimeters should be made. A minimum of two will need to agree within ±60 m (±200 FT).

Failure to meet this condition will require that the altimetry system be reported as defective, and ATC notified, or contingency procedures applied:

The usual scan of flight deck instruments should suffice for altimeter cross-checking on most flights; and

Before entering RVSM airspace, the initial altimeter cross-check of primary and standby altimeters should be recorded.

In normal operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude reporting transponder transmitting information to ATC.

If the pilot is notified by ATC of a deviation from an assigned altitude exceeding ±90 m (±300 FT) then the pilot should take action to return to cleared flight level as quickly as possible.

The pilot should notify ATC of contingencies (equipment failures, weather) that affect the ability to maintain the cleared flight level and coordinate a plan of action appropriate to the airspace concerned. The pilot should refer to the guidance on contingency procedures contained in the relevant publications dealing with the airspace.

Examples of equipment failures that should be notified to ATC are: failure of all automatic altitude-control systems aboard the aircraft; loss of redundancy of altimetry systems; loss of thrust on an engine necessitating descent; or any other equipment failure affecting the ability to maintain cleared flight level.

The pilot should also notify ATC when encountering greater than moderate turbulence

If unable to notify ATC and obtain an ATC clearance prior to deviating from the cleared flight level, the pilot should follow any established contingency procedures for the region of operation and obtain ATC clearance as soon as possible.

In Oceanic airspace for example if you cannot get prior clearance and need to deviate for a non-weather reason then in general terms, you'll need fly an offset level and track where conflicts are less likely to be encountered.

More specifically you should leave the cleared track by initially turning 30° left or right to establish a parallel track at 5NM, or in metric 9.3km, spacing. The direction is determined by one or more of the following:

- Position relative to any organised track or ATS route system
- The direction of flights and flight levels allocated on adjacent tracks
- The direction of an alternate
- Any strategic lateral offset being flown, and
- Terrain clearance

You should then maintain a visual lookout as well as reference to TCAS, turn on all exterior lights for visibility and squawk 7700 along with the appropriate emergency function on the ADS-B/C if you have it.

Use a PAN or MAYDAY as appropriate and remember that CDPLC may be used if available while also calling on 121.5 and potentially 123.45 to alert the traffic around you.

If you are unable to maintain level then initially minimize the ROD to what is operationally possible and once established on the offset either descend below FL290 and establish a 500ft, or 150m, vertical offset from the FL normally used and then proceed as required operationally, or through a clearance if ATC comms are established OR; if remaining in RVSM airspace establish that same vertical offset and again proceed with your operational requirement or ATC clearance if you have now obtained one.

Weather deviations are a little different in Oceanic airspace and we'll look briefly at what is required should you be unable to get a clearance and have to exercise the authority of the PIC under the provisions of ICAO Annex 2.

Until an ATC clearance can be achieved you should:

- Deviate away from an organised ATS route system
- Use 121.5 and as a backup 123.45 to alert aircraft around you
- Watch for traffic visually and using TCAS
- Turn on all exterior lights possible

Then for deviations less than 5NM, or that 9.3Km, from the cleared track you should maintain current level. For deviations greater than, or equal to those numbers you should initiate a level change.

For cleared Easterly tracks ie those between 000° and 179° inclusive, if you deviated left you descend 300ft, or 90m and if right you would climb 300ft or 90m. The opposite applies for those Westerly tracks between 180° and 359° inclusive.

This is a lot to remember so for me I look to remember just one and then I can figure out the rest from there. My brain is too small to remember all four and Mark can barely remember his name after one of these podcasts. I haven't got enough acronyms so I added one here using the word WORD. Yes, I didn't just repeat myself accidentally I use WRD to remember West, Right, Descend and then the rest falls in line. Use it if you want or find something that sticks with you as thumbing through the Gens at a time like this wouldn't be easy! Another sensible thing to do is mentioning this in your cruise brief if it's applicable to the day so the procedure is fresh in your heads as a crew and your both on the same page should it be necessary.

When returning back to your route you should look to be at cleared Flight Level when approximately within 5nm of the centreline. Always continue to attempt to make contact with ATC throughout.

Should one of the primary altimeter system fail or is not reliable:

- You are required to engage automatic altitude control system and switch transponder to the operative system,
- Notify ATC, and
- Maintain vigilance of altitude keeping.

Should all of the primary altimeter systems fail or are considered unreliable:

- Maintain altitude by reference to standby altimeter,
- Watch for conflicting traffic,
- Alert nearby traffic by making maximum use of exterior lights and by broadcasting position, flight level and intentions on 121.5 MHz (or air-to-air frequency as a back-up),
- Notify ATC of the inability to meet RVSM performance requirements,
- Consider declaring an emergency and request clearance to exit RVSM airspace, and
- If ATC clearance cannot be obtained in a timely manner, execute the regional contingency manoeuvre to leave the assigned track or route according to the Airway Manual.

There are specific RT communication phraseology which must be adopted when within RVSM to/from the pilot concerning RVSM operations. We'll put a link on b737talk.com with a reference to the manual for those specific calls.

Phrase	Meaning
(Callsign)…..CONFIRM RVSM APPROVED?	For a controller to ascertain the RVSM approval status of an aircraft.
NEGATIVE RVSM*	For a pilot to report non-RVSM approval status: I. on the initial call on any frequency within the EUR RVSM Airspace (*controllers shall provide a readback with this same phrase)*; and II. in all requests for flight level changes pertaining to flight levels within the EUR RVSM Airspace; and III. in all read-backs to flight level clearances pertaining to flight levels within the EUR RVSM Airspace. Additionally, except for State aircraft, pilots shall include this RTF phrase to read-back flight level clearances involving the vertical transit through FL 290 or FL 410.
AFFIRM RVSM*	For a pilot to report RVSM approval status.
NEGATIVE RVSM STATE AIRCRAFT*	For a pilot of a non-RVSM approved State aircraft to report non-RVSM approval status, in response to the RTF phrase (*callsign*) CONFIRM RVSM APPROVED.
(Callsign)…. UNABLE CLEARANCE INTO RVSM AIRSPACE, MAINTAIN [*or* **DESCEND TO,** *or* **CLIMB TO] FLIGHT LEVEL** *(number)*	Denial of ATC clearance into the EUR RVSM Airspace.
UNABLE RVSM DUE TURBULENCE*	For a pilot to report when severe turbulence affects the aircraft's capability to maintain the heightkeeping requirements for RVSM.
UNABLE RVSM DUE EQUIPMENT*	For a pilot to report that the aircraft's equipment has degraded below the MASPS required for flight within the EUR RVSM Airspace. *(The phrase is to be used to convey both the initial indication of the non-MASPS compliance and henceforth, on initial contact on all frequencies within the lateral limits of the EUR RVSM Airspace until such time as the problem ceases to exist or the aircraft has exited EUR RVSM Airspace)*

READY TO RESUME RVSM*	For a pilot to report the ability to resume operations within the EUR RVSM airspace after an equipment or weather-related contingency.
REPORT ABLE TO RESUME RVSM	For a controller to confirm that an aircraft has regained its RVSM approval status, or to confirm that the pilot is ready to resume RVSM operations.
(* indicates a pilot transmission)	

Should you have a comms failure in RVSM airspace, The ICAO Regional Supplementary Procedures for Europe specify that the applicable vertical separation minimum between an aircraft experiencing a communication failure in flight and any other aircraft, where both aircraft are operating within the EUR RVSM Airspace, shall be 600 m (2000 ft), unless an appropriate horizontal separation minimum exists.

So that's about it, a brief look at RVSM operations and the generic requirements for operating within this type of airspace. We of course can't leave you without announcing the winner of last week's competition from flying fit ltd. Congratulations to Harry White, we'll be in touch shortly with Ben's contact details for you to claim your health and nutrition programme from him. We have some more exciting competitions coming up so please keep liking those podcast episode posts for your chance to win.

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