Mitigating Pilot Deviations on TEB RUUDY 6 Departure

by Capt. Jim Dramis

Despite the numerous educational and procedural-improvement efforts associated with the RUUDY 6 Departure, lateral and vertical pilot deviations continue to occur at a concerning rate.

As with any procedure, successfully negotiating the RUUDY 6 requires a combination of:

1. Carefully reading and understanding the information depicted on the chart,
2. Managing Lateral guidance,
3. Managing Vertical guidance,
4. Understanding your aircraft's performance, FMS and Autoflight, and
5. Managing CRM and division of tasks.

This article will discuss all of the above considerations, as well as a few others. We may even have a little fun in the process.

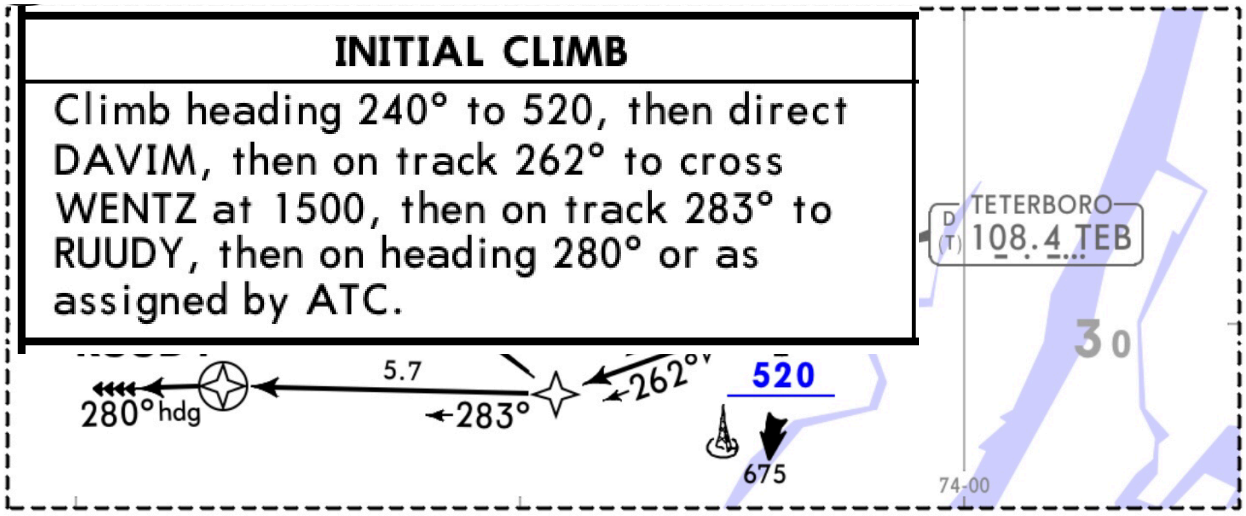
STEP 1: It Starts with the Chart

The first step is to build an accurate 3-dimensional mental picture of the procedure. This can only be accomplished with a clear understanding of the charting conventions for the product you're using, and a solid knowledge of IFR fundamentals. Here, we will use Jeppesen digital charts.

Although a thorough review of chart symbology is beyond the scope of this article, here are a few things to look for, and to revisit as needed:

- **Headings vs. RNAV courses.** As shown in both the plan view and the textual description, we're expected to fly heading 240 degrees until 520' MSL, at which point we transition to RNAV guidance direct to DAVIM, then WENTZ, then RUUDY. Once passing RUUDY, we must revert back to Heading mode to comply with the 280-degree requirement.

That's a lot of mode changes happening in a short period of time — and we haven't even covered the vertical aspect yet!



- **"Climb Via" Clearance, Top Altitude, and Altitude Restrictions.** The typical IFR clearance out of TEB will start with, "Cleared to the XYZ airport via the RUUDY6 departure, then as filed. Climb via the SID..." But what exactly does "Climb via SID" mean?

Quite simply, "Climb via SID" means that you must navigate the procedure, as published, both laterally and vertically (up to the Top Altitude, or another altitude if instructed by an "…except maintain XXXX feet" clearance), while complying with any altitude and speed restrictions depicted on the chart — unless the controller (1) explicitly tells you to "delete" such restrictions, or (2) assigns you a higher "Climb and maintain" altitude, which implicitly cancels the "Climb via" clearance.

Now that we understand the Climb Via clearance, what is the Top Altitude? This is found ***only*** in the textual description of this particular procedure, and is 2,000 feet in this case:

INITIAL CLIMB	TOP ALTITUDE
Climb heading 240° to 520, then direct DAVIM, then on track 262° to cross WENTZ at 1500, then on track 283° to RUUDY, then on heading 280° or as assigned by ATC.	2000

NOTE: We've heard of situations where the crew climbed to an initial altitude of 3,000 feet. So please don't confuse the big, bold "3000 MSA TEB VOR" in the plan view (above the airport symbol) with the Top Altitude! The 3,000' Minimum Sector Altitude (which provides 1,000' of obstacle clearance at all points within a 25nm radius of TEB VOR — bonus points if you remembered that from your IFR training days) is for situational awareness and emergency purposes only, and is ***not*** to be used as a procedural altitude while navigating the departure.

So if the Top Altitude is 2,000 feet, does this mean we can climb straight up to that altitude? ***ABSOLUTELY NOT*****!**

Remember that "Climb via" requires us to comply with any altitude restrictions along the way. And we have an important one: we ***must*** cross WENTZ ***at*** 1,500 feet — not above it, and not below. (Once airborne, we can cross it above 1,500' only if, as discussed previously, ATC issues a new "Climb and maintain" altitude prior to crossing WENTZ, which implicitly cancels any of the SID's remaining altitude restrictions.)

The 1,500' constraint at WENTZ is a ***mandatory*** altitude. As shown in the above photos, it's depicted on the chart in two ways:

1. The "…cross WENTZ at 1500" verbiage in the textual description, and
2. The blue **1500** sandwiched between two horizontal blue lines in the plan view. (Recall that the enhanced Jeppesen charting format depicts Altitude restrictions in **BLUE**, and Speed restrictions in **MAGENTA**, so these colors should ***always*** command your attention.)

Once we've crossed WENTZ at 1,500 feet, there are no further constraints, meaning that we can finally climb to the Top Altitude of 2,000 feet. But be careful…don't climb too early! Since WENTZ is a fly-by

waypoint, the aircraft will begin turning toward RUUDY ***prior*** to crossing WENTZ. So don't start climbing as soon as the aircraft starts turning, because you haven't actually ***passed*** WENTZ yet, and you might earn yourself a vertical deviation on this sneaky technicality. I wait until the wing of my moving map's aircraft symbol (at about a 2.5-mile scale) is abeam WENTZ to ascertain waypoint passage before beginning the climb, but that's just my technique.

STEP 2: Lateral Navigation

Unless you're flying a very sophisticated FMS and Autoflight system that automatically transitions between HDG (Heading) and LNAV (Lateral NAVigation) modes, you may need to do a bit of button-pushing to assure lateral compliance with the RUUDY 6. But the departure phase of flight is fraught with distractions — you're retracting gear and flaps, changing frequencies, and dealing with new ATC instructions, all while attempting to monitor the aircraft's trajectory for DP compliance. It's easy to see how things could go awry very quickly.

The question is, what is the ***minimum*** amount of button-pushing and mode-changing that you can do to get the job done, while still adhering to the recommended practices and limitations for your aircraft and avionics?

The RUUDY 6 starts with a heading of 240 degrees until 520', and then quickly requires a transition to LNAV guidance direct to DAVIM. You might be tempted to select HDG mode for departure. While technically correct, there could be problems with using HDG mode.

Since a right turn is required at DAVIM (technically just before it, since it's a fly-by waypoint) to navigate the next RNAV course to WENTZ, it's clear that a late activation of LNAV guidance — or forgetting to activate it at all, in the heat of battle — might cause us to delay or even miss this turn completely, resulting in a lateral bust. Sharpen your pencil and get ready to copy a phone number.

An important question to ask yourself is, "How does my FMS sequence the waypoints in this departure?" Honeywell FMS units will satisfy the first leg of the procedure (takeoff to 520') as a Course to Altitude (CA) leg, and will display the point where you're projected to reach 520' as ***ALT01**, colloquially known as a "floating" waypoint. (You'll see this fix in your FMS waypoint list just before DAVIM.) Once airborne, the FMS will continue updating the computed position of *ALT01 based on your actual climb path.

Why do you need to know this? Because an overly-shallow climb might actually push *ALT01 ***past*** DAVIM. If this happens, the FMS will fly right by DAVIM, continue to the active *ALT01 waypoint, and then initiate a 180-degree turn ***back*** to DAVIM, which is now ***behind*** you! I suspect that more than a few lateral deviations may have been due to this phenomenon. **Honeywell has an excellent article about this particular quirk.**

My experience is primarily in the Falcon EASy II aircraft. After flying this procedure many times in both the simulator and in the real airplane, I can state confidently that engaging LNAV mode on the ground, flying that guidance all the way to RUUDY, and using a reasonable (but not excessive, as we'll see shortly) climb rate to satisfy the published gradient works 100% of the time.

Of course, your FMS and Autoflight systems might work differently, so it comes down to knowing — through a combination of study, training, and experience — which procedure works best in your aircraft, as well as understanding the idiosyncrasies of your FMS.

STEP 3: Vertical Navigation

The lowest-hanging fruit in terms of avoiding an altitude violation begins with setting the correct initial ASEL in the first place. The correct answer here is 1,500' to comply with the published restriction at WENTZ. Yes, it may be possible to set 2,000' and utilize your VNAV capabilities — if you fully understand it and are proficient with it — but one could correctly argue that you're just adding an additional level of automation complexity, and therefore one more thing that might go wrong. When in doubt, I recommend utilizing a lower level of automation. Setting 1,500' and saving your fancy VNAV for the STAR gives you one less thing to worry about.

Managing a high-performance aircraft's vertical trajectory isn't always easy. We have considerations for obstacle clearance, noise abatement, and required SID climb gradients. It generally behooves us to get as far away from the ground as quickly as possible, which in turn requires a high climb rate.

But to comply with the relatively low 1,500' ***mandatory*** altitude at WENTZ, we cannot pitch the nose way up at full power into some astronomical 4,000-fpm climb. I've seen this done in the simulator on the RUUDY6, and it never ends well. You're begging for an overshoot with aggressive climb rates. Climb at a rate consistent with satisfying the required SID gradient and any noise abatement procedure, but keep it manageable.

In the Falcon 900LX and 2000LX that I fly, Dassault recommends using Takeoff Mode for every departure (basically giving you pitch guidance for maintaining V2+10 until TOSA). This mode provides vertical guidance for a 4-segment climb in the unlikely event of an engine failure, which is good, but it can also result in some spectacular climb rates just after liftoff, which is ***very*** bad for the RUUDY6. This sets the stage for an altitude bust right out of the gate. If you're not on your game, flying the Flight Director very tightly, and maintaining the "big picture" vertically, you're very likely to overshoot your target altitude.

Once again, intentionally reducing the aircraft's climb rate to a reasonable value (while still satisfying the published climb gradient to 520') cannot be overstated. Remember that aircraft landing on Runway 22L at Newark Liberty (KEWR), just south of TEB, are overflying you at just 2500'. You don't want an excessive climb rate to trigger a TCAS RA for the aircraft just above you.

Also, keep in mind that you're below Class B airspace during this departure, so you're speed-limited to 200 KIAS. Besides making it more difficult to level off, high power settings will increase the likelihood of a speed violation as the nose lowers. This departure moves pretty quickly even when flying relatively slowly, so why make things worse with unnecessary excess speed? For most jets, consider something around 170 to 180 KIAS maximum until completing the turn at WENTZ, unless a higher speed is necessary for safety.

Another very important consideration involves when to engage the Autopilot. It's no secret that high levels of automation can sometimes get you into trouble, and the RUUDY6 is a prime example of that.

All autopilots have G-limits that regulate how aggressively they can push the nose down. Suppose you're climbing at 3,000 fpm though 1,000', then engage the Autopilot in the hope that it will capture your 1,500' initial altitude. The Autopilot isn't going do a zero-G pushover to satisfy your ASEL setting. Chances are good that you will have an altitude bust. Grab yourself a pen and paper and copy that phone number again.

If you're going to engage the Autopilot during the climb to 1,500', please do so ***only*** when:

1. The aircraft is under control, stable, and properly trimmed,
2. Thrust has been set to a value appropriate for the climb profile, and
3. You're at an altitude and climb rate that will provide the Autopilot adequate time to capture the 1,500' initial altitude.

My technique — and it's just that, a technique — is to initially set 1,500' in ASEL, reduce power shortly after liftoff but not below Minimum Action Altitude, and limit my climb rate to 1,500 fpm, regardless of what my Flight Director is initially commanding. If I feel that I'm properly trimmed and still low enough to avoid an Autopilot-induced overshoot, then I'll engage the AP…but if not, I'll smoothly hand-fly the level-off. This technique has kept me well clear of trouble thus far.

STEP 4: Performance and Autoflight Capabilities & Limitations

We've already talked extensively about flying this procedure in a high-performance aircraft. Unlike most departures, high speeds and climb rates are your enemies here. The better you manage your energy and slow down the speed at which things happen, the better off you'll be.

As far as automation goes, it can either can help you, or it can hurt you. You need to know ***which*** modes to use, ***when*** to use them, and exactly ***what*** they're going to do. This is not the time for surprises. There isn't much room for error on the RUUDY 6. There's no time to ask "NOW what's it doing??!" when you engage the autopilot.

As with any other phase of flight, mode awareness is critical. How you manage the automation can spell the difference between a routine departure, and a conversation with the FAA. So brief the departure carefully, and discuss with the other pilot (if there is one) exactly how you plan to execute the procedure.

STEP 5: CRM — Who Does What?

Even for a 2-pilot crew, the RUUDY 6 will require very careful coordination, particularly if it's combined with another demanding procedure like a close-in noise abatement departure.

The CRM aspect should, at a minimum, include:

- A thorough review of the departure chart to create a shared mental model of the procedure, with emphasis on altitude restrictions, speed restrictions, and other potential "gotchas."
- Discussion of which Autoflight modes will be used, and how a reduction in automation level should be accomplished if the selected mode doesn't provide the desired result.
- Assignment of cockpit tasks and choreography, e.g. who will reduce thrust, when to retract flaps, etc.
- Confirmation by both pilots that the appropriate runway, procedure, waypoints and constraints are loaded into the FMS.
- Re-verification of ASEL, and active/armed Autoflight modes, just prior to departure.
- Displaying the moving map at a scale appropriate for the procedure, and monitor it for SID compliance.
- Encouraging the PM (Pilot Monitoring) to immediately verbalize any concerns regarding aircraft trajectory, energy state, and SID compliance.
- Monitor Autoflight modes, and verbalize any mode changes.
- If SID compliance has been jeopardized, then revert to HDG or TRK mode, attempt to regain orientation with the SID using your moving map, and notify ATC immediately.
- Emphasize the need to AVIATE, NAVIGATE, COMMUNICATE — in that order.

Summary

Successfully negotiating the RUUDY 6 Departure is a tournament-level exercise in chart interpretation, automation usage, FMS knowledge, CRM, energy management, pilot technique, general airmanship, and…yes, a bit of finesse.

Before attempting this procedure in an actual aircraft, seek simulator training in the appropriate type, preferably with avionics similar or identical to what's installed in your airplane. Take that training opportunity to experience the departure at different gross weights, winds, ambient conditions, and climb rates to learn how those variables affect your ability to fly the procedure. Learn and master the automation techniques that will provide you with the best chances to successfully and consistently execute the procedure as published. Keep trying until you can reproduce it correctly over and over.

I promise your sim instructor won't give you a phone number to copy if you don't get it right the first few times.

If you have any experiences with the RUUDY 6 that you'd like to share, or have any questions or comments on this article or the procedure itself, please don't hesitate to contact us here at Teterboro Users Group. Safe flying!