The Net-SID Method

A.Scope

This document will define and substantiate the use of an alternative method of complying with FAR 135.379 one-engine inoperative obstacle clearance.

B.Background

Charter operators must prove that in the event of an engine loss, the aircraft can clear obstacles by 35ft vertically on a Net Takeoff Flight Path. This is the essential requirement of 135.379.

Advisory Circular 120-91(appendix A) describes a method for complying with obstacle clearance requirements defined within FAR 121.177, 121.189, 135.367, 135.379, And 135.398. That method is commonly referred to as runway analysis and relies upon obstacle identification through independent surveys and the creation of takeoff path corridors, ostensibly over lower terrain. These flight paths may diverge from the published departure procedure and typically involve holding at a fix or navaid. Flight track construction is defined within the circular and involves far narrower margins as compared to standard departures. For instance, the initial obstruction clearance area under AC120-91 is 400ft width at the departure end of the runway (DER) while the same area is 1000ft wide under TERPS. Further, the splay area of 16:1 (~3.5 degrees) begins 4800 ft from the DER and continues out to 2000 ft while the 15 degree splay under TERPS begins at the DER and extends out to 2 miles.

Flight paths provided through various commercial vendors of such analyses, are typically not flight tested in actual aircraft or even in simulators, even though the circular highly recommends both of these actions to comply with individual operator requirements and pilot experience. In fact, the technical evaluation and risk assessment of proposed instrument operations (under AC 120.91) are not covered by standard criteria.

The most restrictive, and oft overlooked, issue with utilizing third-party runway analysis procedures is that the vast, vast majority of flight management systems (FMS) are incapable of selecting an RNP of less than 1.0 when manually entering "alternate departure procedures". The mere fact that AC 120-91 itself defines the obstacle accountability area (OAA) of these procedures to be only 2000ft from the centerline, mandates an RNP of no more than 0.3. Utilizing an RNP of 1.0 on such alternative procedures could place the aircraft outside the protected area without any crew alert, even while the PFD shows the aircraft to be on the magenta line.

Due to the narrower margins of safety, the variability in design of flight tracks and the basis of navigating the modified procedure, runway analysis requires higher pilot proficiency, training, aircraft capability and awareness.

The advisory circular also acknowledges that runway analysis is not the only method that provides compliance to the regulatory obstacle clearance. The procedure that will be defined in this article will provide superior obstacle clearance, easier compliance by operators and simpler procedures for pilots.

C.The Basics

As is often stated during discussions on this subject, TERPS does not meet part 135.379 and 121.189 obstacle clearance requirements. This is offered so often that one begins to believe that TERPS doesn’t provide obstacle clearance at all. The reality of the disparity between TERPS and 135.379 / 121.189 is actually only observed under Order 8260.3B pre-change 19 (“Old TERPS”) and post-change 19 (“New TERPS” Appendix C) when using wet runway data. The non-compliance has nothing to do with TERPS all-engines operating intended utilization. The obstacles beneath TERPS departures do not “know” how many engines are operating.

Under “Old TERPS”, departures were designed initially and foremost with obstacle clearance in mind. The basic obstacle clearance requirement was established by creating an imaginary surface that extended from the runway surface and 500 feet to either side with a (15 degree outward splay) and upwards at a 40:1 “angle”. If no obstacles penetrated the surface, which we’ll refer to as an Obstacle Identification Surface or OIS, the standard climb gradient of 200ft/NM was established. The slope is increased to encompass (pass over) all obstacles. However, a 40 to 1 sloping surface, defining the inclusion of all obstacles, is not 200ft/ NM but 152ft/NM (6076ft/NM divided by 40). So where does the extra 48ft/NM come from? This

This .8% has no equivalent under one-engine inoperative requirements (135.379 or 121.189) which are concerned only with clearing “known” obstacles. Due to the wider and greater splay angle of the TERPS departure corridor, compared to AC120-91 requirements, the TERPS criteria would offer a more conservative representation of obstacle clearance since more obstacles would in fact be considered.

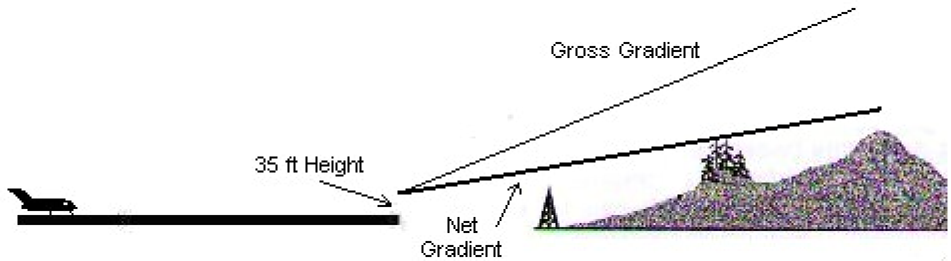


Figure C1

The oft referred to failure of TERPS to comply with 135.379 and 121.189 is entirely based on the 35ft clearance requirement. If all TERPS departure procedures started at the runway surface and close-in obstacles did not exist, the 35ft clearance would be automatically complied with by virtue of the fact that Part 25 (and commuter Part 23) aircraft certification defines a reference height of 35 ft at the runway end. Unfortunately, a provision within the “Old TERPS” allowed TERPS designers to raise the runway end starting point of the published 40:1 slope Obstacle Identification Surface (or Net Gradient) to 35ft. This was necessary to prevent certain close-in obstacles from essentially “shutting down” instrument departures due to excessively steep climb gradients. The logic of this design exception is that since the aircraft will be at 35ft, at a minimum by certification requirements, the safety margin required by TERPS would be met. This causes a problem with 135.379, however, which requires the one-engine inoperative aircraft to be 35 above any obstacle. If the aircraft were to be at 70ft at the end of the runway, part 135 obstacle requirements would be met.

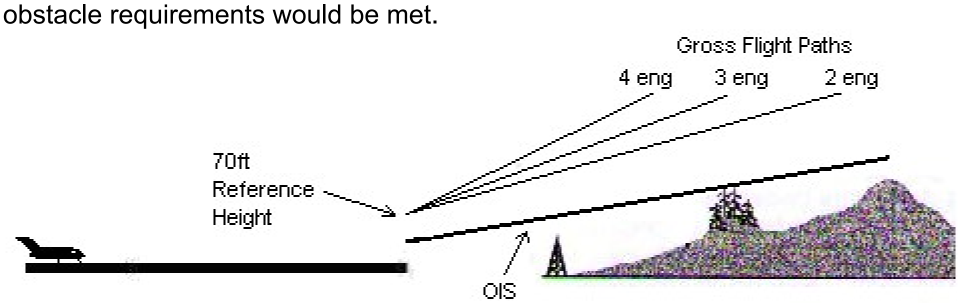


Figure C2

Under “New TERPS”, the Obstacle Identification Surface, now called an Obstacle Clearance Surface (OCS or Net Gradient) always starts at the runway surface which greatly simplifies the 135.379 / 121.189 compliance issue. Note: The current release of 8260.3B, under Vol 4, §1.2 provides an exception to this rule that allows the surface 40:1 slope to be raised to 35ft, as under the old rule; however it has been revoked under an AFS-420 memorandum dated March 17, 2005 (appendix B).

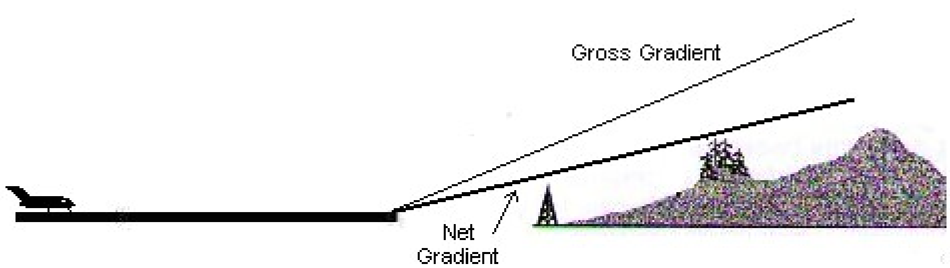


Figure C3

Under both TERPS criteria, the performance reference height for wet runway operations must be addressed to account for adequate (35ft) obstacle clearance. Part 25 certification sets the reference height for wet runway (not contaminated runway) operations to 15ft. Thus for "Old TERPS" the runway end crossing height must be 70ft while under "New TERPS" the crossing height must be raised to 35 ft under wet runway conditions only.

As there is no pilot identifiable determinate to whether the runway surface or 35ft OIS is used under "Old TERPS", the exercise to raise the reference height to 70ft must be performed on all departures. ICAO standards utilize departure criteria similar to the "Old TERPS" criteria.

Another major distinction between old and new TERPS is the safety margin. As stated above "Old TERPS" (and ICAO) use a standard 48ft/NM safety margin regardless of how steep the obstacle identification surface is determined to be.

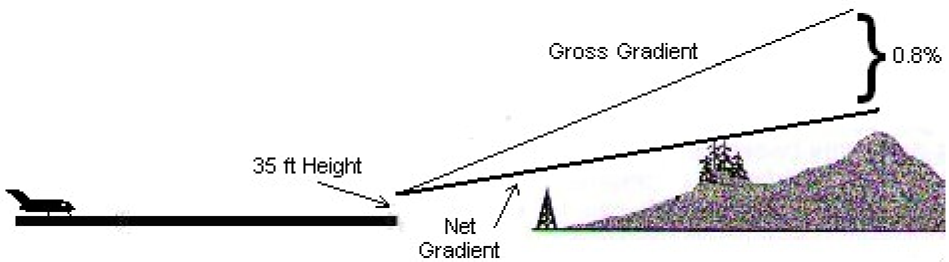


Figure C4

Under "New TERPS" the safety margin is a percentage of the overall gross gradient. While the percentage is fixed, 24%, the ft/NM will increase with steepness of gradient. At the minimum climb requirement (200ft/NM) the safety margin remains at 48ft/NM (24% of 200). Increasing the gradient to 400ft/NM subsequently increases the safety margin to 96ft/NM under "New TERPS".

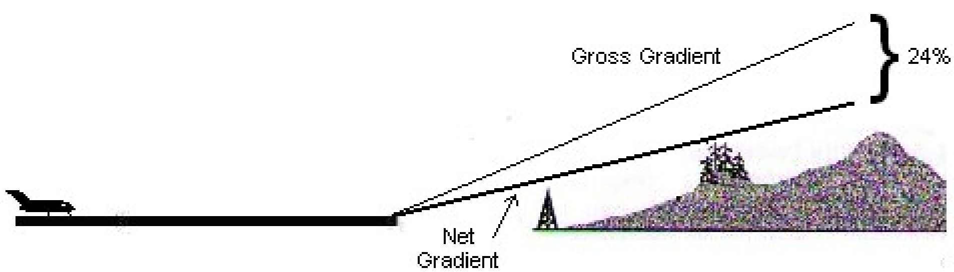


Figure C5

But remember obstacle clearance under 135.379 has no such safety margin equivalent using instead a standard 35ft over obstacles. Further revisions of TERPS are likely to return the safety margin to a standard 48ft/NM.

<u>D. Benefits to Using The Net-SID Method</u>
The Net-SID method affords several benefits over AC120-91 type runway analysis.

1. The strength of the Net-SID method is that the pilot flies the published and familiar departure procedure whether the aircraft experiences an engine loss or not. This simplicity reduces pilot workload, confusion and training requirements to that regularly encountered under normal proficiency requirements. Complex dual FMS set ups and crew briefing (i.e. transfer of control from the pilot flying to the pilot not flying, etc) is entirely avoided.
2. There is no ambiguity when the "entrance window" of a deviating runway analysis procedure closes. Runway analysis procedures often utilize flight tracts that diverge from the published procedure. Pilot awareness of when this point is passed is often missing. AC120-91 departures are limited to the climb altitudes obtainable and must often utilize

holding patterns that may be positioned between mountain ranges or aligned with approach procedures of other airports. With the Net-SID method, the engine failure can occur at any point along the departure procedure and still assure obstacle clearance.

3. The Net-SID method can be ported to any existing procedure both in and outside the US without adding documentation beyond the required departure plate or description. This also has the added benefit of keeping the flight crew situationally aware in the obstacle clearance calculation process versus simply listing a weight for a runway with the pilots unfamiliar with the safety tolerances guaranteed by the procedure.
4. The departure construction criteria of TERPS is vastly conservative compared to runway analysis departures and thus specific aircraft one-engine-inop performance tracks, as described within AC120-91, comfortably fit within the standard procedures. This safety tolerance is true under all weather and wind conditions while at the same time maximizing safe payloads. While runway analysis may have the benefit of allowing heavier takeoff weights, under some conditions, it is done so at the expense of lower flight track altitudes, narrower lateral safety margins and narrower flight path widths all of which must be followed in IMC conditions with one-engine inoperative.
5. Unlike third party constructed "escape procedures", the Net-SID method results in alleviating the AC 120-91 recommended operator flight and simulator testing of each procedure. By virtue of the fact that the Net-SID procedure utilizes a published procedure, the governing agency (FAA) regularly flight tests each procedure and the navigatibility of the procedure fall within the abilities of all affected pilots.
6. The Net-SID method assures that the aircraft is delivered into the enroute structure without holding, regardless of how high an altitude the procedure extends.
7. The cost of third party subscription services and enhanced procedure simulator training, which are substantial and re-occurring, is eliminated.

E. Net Takeoff Flight Path

Both 135.379 and Part 25 certification requirements are based on a Net Takeoff Flight Path. This path is the basis of all AFM performance takeoff calculations. In order for the performance numbers obtained through the performance charts to be meaningful, the pilot must strictly adhere to flying the Net Takeoff Flight Path profile. Flying this profile by adhering to V speeds and level off altitudes assures that the Net Flight Path is obtained and thus makes possible the assurance of obstacle clearance. Pilots who defiantly claim that they "will never lower the nose (level off to accelerate) if an engine is loss" or who utilize methods that ignore the acceleration / level-off / third segment all together are inadvertently invalidating all the performance numbers both the AFM and FMS present, including V speeds and max weights. Limiting 2nd segment climb altitudes allowed by the AFM and the incorporation of a level-off altitude, observing engine time limits and enroute segment are hallmarks of approvable Net Flight Path calculations.

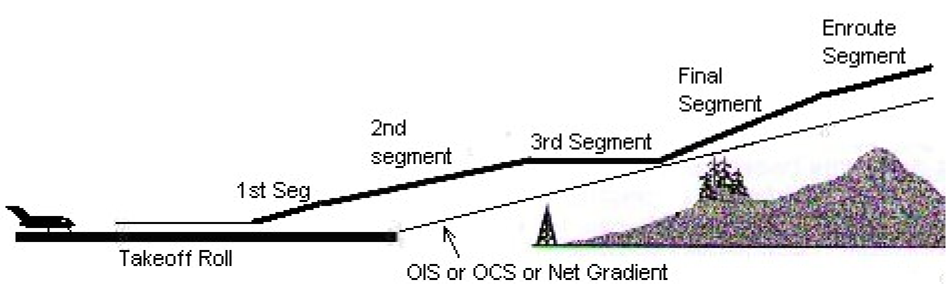


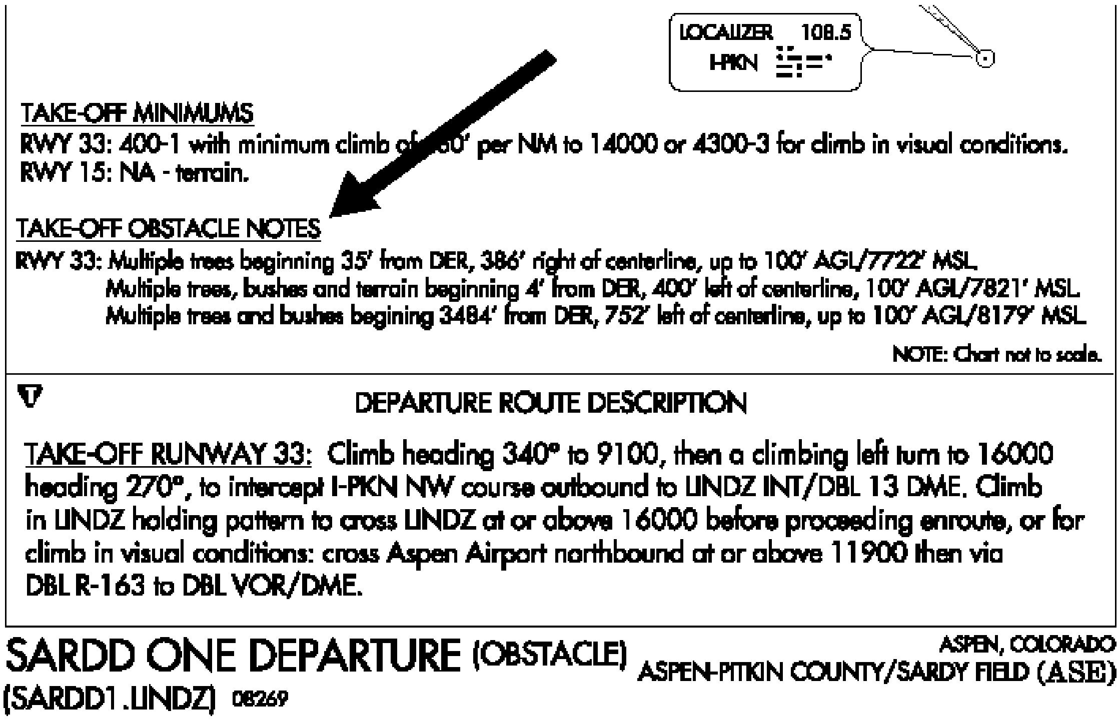
Figure E1

F. The Calculation

Using the Net-SID method requires the ability to track several variables simultaneously while also calculating multiple performance charts iteratively. If the calculation is performed manually, the potential for error is enormous and the process restrictively time-consuming. Computers, however, are particularly well-suited to this type of calculation. The steps and considerations for this calculation are discussed below, assume a 400ft/NM to 8000ft departure procedure.

1) Determine the type of departure procedure used (i.e. "Old TERPS" or "New TERPS").

a. If operating within ICAO controlled environment, all departures can be considered “Old TERPS” utilizing the .8% safety margin.
b. Within the US, departures can be classified as “New TERPS” if the published departure procedure contains “TAKE-OFF OBSTACLE NOTES”.


LOCALIZER 108.5
I-PKN

TAKE-OFF MINIMUMS
RWY 33: 400-1 with minimum climb o[illegible]0' per NM to 14000 or 4300-3 for climb in visual conditions.
RWY 15: NA - terrain.

TAKE-OFF OBSTACLE NOTES
RWY 33: Multiple trees beginning 35' from DER, 386' right of centerline, up to 100' AGL/7722' MSL.
Multiple trees, bushes and terrain beginning 4' from DER, 400' left of centerline, 100' AGL/7821' MSL.
Multiple trees and bushes begining 3484' from DER, 752' left of centerline, up to 100' AGL/8179' MSL.

NOTE: Chart not to scale.

DEPARTURE ROUTE DESCRIPTION

TAKE-OFF RUNWAY 33: Climb heading 340° to 9100, then a climbing left turn to 16000 heading 270°, to intercept I-PKN NW course outbound to LINDZ INT/DBL 13 DME. Climb in LINDZ holding pattern to cross LINDZ at or above 16000 before proceeding enroute, or for climb in visual conditions: cross Aspen Airport northbound at or above 11900 then via DBL R-163 to DBL VOR/DME.

SARDD ONE DEPARTURE (OBSTACLE) (SARDD1.LINDZ) 08269
ASPEN, COLORADO
ASPEN-PITKIN COUNTY/SARDY FIELD (ASE)

This note section, only found on procedures flight tested under change 19 criteria, contains reference to individual obstacle distances from the runway end and laterally from the centerline. See example Appendix A

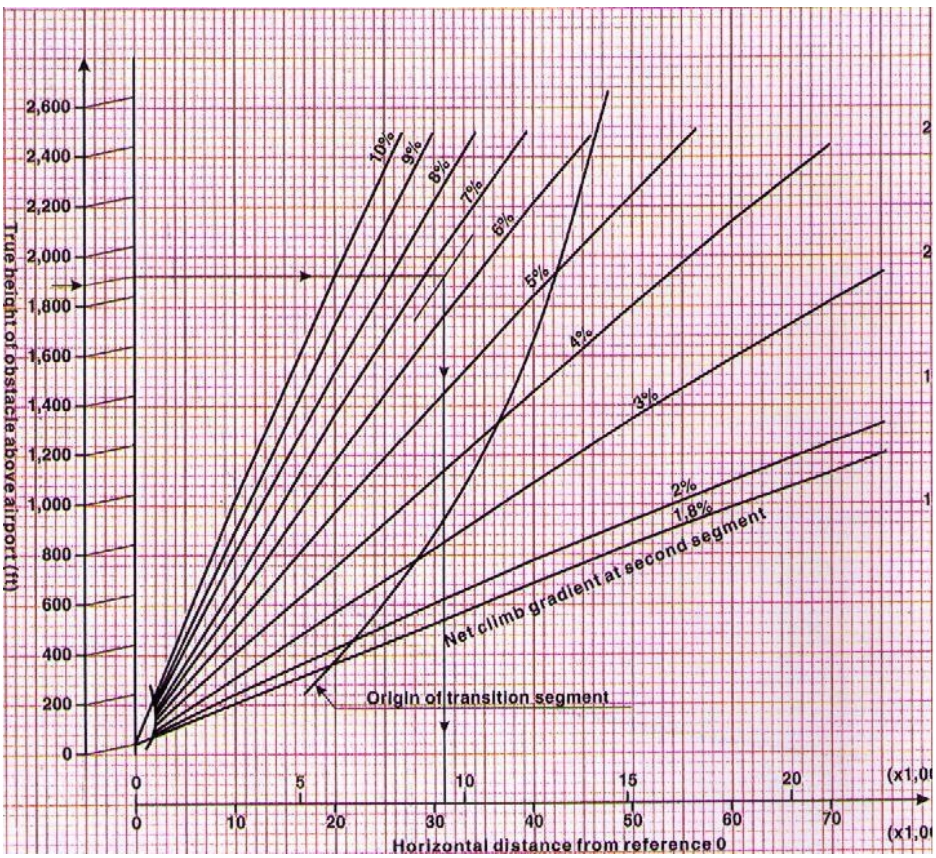
c. Whenever in doubt the pilot can utilize “Old TERPS” criteria, as this will provide conservative results even when applied against post change 19 (“New TERPS”) departures.

2) “Net-ify” the TERPS gradient
   a. If “Old TERPS” is utilized, simply subtract .8% from the required gradient. The required gradient is obtained by dividing the climb in ft/nm by 6076 and multiplying by 100 (For example, a 400ft/nm climb requirement is a 6.6% gross gradient. Subtracting .8 from the gross gradient renders a Net gradient of 5.8%)
   b. If “New TERPS” is utilized, multiply the climb requirement (i.e. 400ft/nm) by 24%. Subtract this amount (96ft) from the climb requirement (400-96=304) and divide that value by 6076 and multiply by 100. In this example, a 5% Net gradient is obtained.
3) Adjust Runway Length for Reference Height
   a. For “Old TERPS”, shorten runway to allow aircraft to climb to a reference height of 70ft by the runway end (DER). This distance is equal to the horizontal distance required to climb 35ft (dry runway) or 55ft (wet runway) with gear and flaps extended. This calculation requires the utilization of the Close-In Obstacle chart found within the AFM.
   b. For “New TERPS”, no adjustment is required for dry runways. For wet runways, shorten the runway by a distance equal to the horizontal distance required to climb 20ft (35-15=20) with gear and flaps extended. This calculation requires the utilization of the Close-In Obstacle chart found within the AFM.
4) Determine Max Weight Limited by Structure, Climb & Brake Energy
   a. These values are certification dependent limiting weights and must be run for departures in VFR as well as IFR conditions.

b. The Max Weight Climb value has nothing to do with the departure gradient weight restriction.

5) Determine the Max Weight Limited by Takeoff Distance
   a. Starting with the max gross weight for the aircraft, determine the takeoff distance.
   b. If the distance is longer than the available runway length, lower the weight and repeat the process.

6) Determine 2nd Segment Max Weight
   a. Start iterative process to determine lowest 2nd segment value from the Distant Obstacle chart with the corresponding distance to accelerate (clean-up) the aircraft that remains above the Net Gradient and whose weight is less than the Max Takeoff Weight determined by Steps 4 and 5.
   b. To determine if the combination of Instantaneous 2nd segment and Acceleration distance stay above the Net Gradient, use the horizontal distance (bottom scale) of the distant obstacle chart corresponding to the net level-off height. Add this distance to the acceleration distance and divide this sum into the net level-off height + 35ft. For example, assume a 1500ft net level-off (1500ft + 35ft) / (6000 ft + 12000ft) is an 8.5% gradient. Compare this value against the Net gradient value. If the Net gradient is less than the value, the aircraft remains above the Net Gradient.



   c. For aircraft that allow variable level-off altitudes, the iterative process can be repeated at various level-off heights but only for those heights found within the limits of the Distant Obstacle chart.
   d. If the runway is long, unused runway (Takeoff Runway Available-calculated takeoff distance) may be subtracted from the horizontal acceleration distance in paragraph c above. It must not be used to lower the overall gradient since 2nd segment increases linearly with weight and the acceleration distance increases logarithmically.

e. Repeat process to minimize the Instantaneous 2nd segment value for this segment. Note: minimizing the instantaneous 2nd segment value is analogous to maximizing the weight.

f. Refer to the Net Segment chart for field conditions existing at the time of departure to determine the max weight that will produce the Instantaneous 2nd segment value determined in paragraph e. Note: As values listed in the Net 2nd Segment charts are certified by the manufacturer at the onset of 2nd segment climb, the degradation of performance with altitude during 2nd segment must be taken into account. This is accomplished by determining the Instantaneous 2nd segment value, required to clear heights downrange, from the Distant Obstacle charts.

g. The gross level off altitude is calculated as the net level off altitude (1500 feet) plus 35 feet plus the field elevation plus the altitude difference between NET and GROSS performance. This difference is aircraft specific and related to the number of engines. For a Twin engine aircraft a .8% derating is applied to gross climb to net climb. See figure C2. Three and four engine aircraft must use .9 and 1% differences respectively. To find the altitude difference, multiple the derate factor by the distance to the third segment from the departure end of the runway. In our example this was 6000ft x .008 or 48ft. So if the field elevation were 1000ft, the gross level-off height would be 1500 + 35 + 1000 + 48 or 2583 ft MSL.

7) Determine the Max Weight for the Enroute Segment

a. Starting at the endpoint of the acceleration segment, determine the gradient required to meet the Net Gradient at the very top of the climb. This is calculated by subtracting the combined 2nd segment and acceleration horizontal distances from the entire departure procedure distance. In the above example, it was determined that 18000ft was required to climb to 1535 ft and accelerate to Venr. The original DP was 400ft/Nm to 8000 ft, which calculates out to be 121520 ft (8000/400 = 20 NM x 6076ft/NM). The remaining climb is 8000-1535 = 6466 ft divided by the remaining distance (121520-18000 = 103500) which is a 6.3 gradient.

b. Use the appropriate Enroute Gradient charts to determine the maximum weight to meet or exceed the required final gradient. Note: As the Enroute Gradient chart calculates the gradient at the departure procedure top altitude (i.e. 8000ft), the chart value must only be equal to or larger than the calculated remaining gradient.

8) Select the Lowest Weight

a. Identify the lowest weight from steps 4-7 to determine the Max Takeoff Weight Allowed.

<u>G. Operational Considerations</u>

The operator should have processes identified within their General Operating Manual for training of pilots/dispatchers and updating of software.

If a Safety Management System is utilized, clear delineation of when appropriate obstacle clearance tools should and should be used. For example, for operators using both the Net-SID and runway analysis methods, a correlation based on weather minima may be employed. Below is such a reasoned approach to bracketing risk elements.

As stated above, runway analysis is based upon the assumption that planning can account for individual obstacles and thus can apply minimum vertical clearance standards (35ft) and narrower lateral margins to construct a path around or away from obstacles. This, by its very definition, will place the aircraft lower to the ground at heavier weights, as denoted by heavy black line in figure G1, than if on a required gradient.

Figure G1

The Net-SID approach, by definition, will utilize much more conservative routes, safety margins and weights as shown, by the larger line, in figure G2.

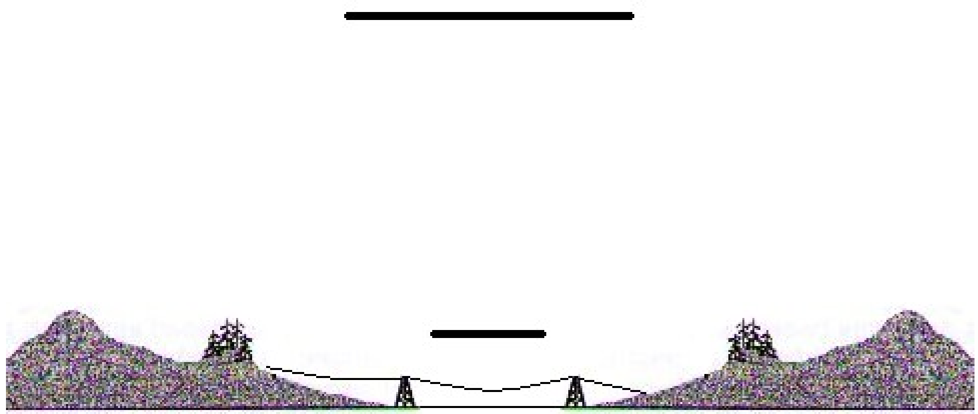


Figure G2

It follows then, that the Net-SID path can be performed at lower risk than the runway analysis procedure, even when following the same path. This risk gradient can be visualized by connecting the paths above with condition vectors. The object of the risk vector is to counteract inherently riskier and unchangeable factors with less risky factors that are controllable.

The vector below is the field elevation vector. The higher the conditions that adversely affects performance, the closer the vector moves toward the less risky Net-SID method.

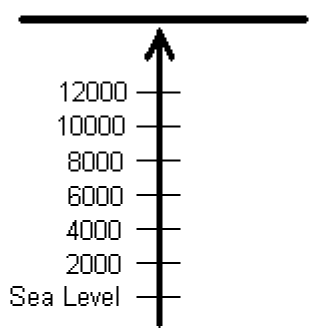


Figure G3

Several such parameters could combined to this matrix, such as temperature and visibility.   The resulting matrix might look like this:

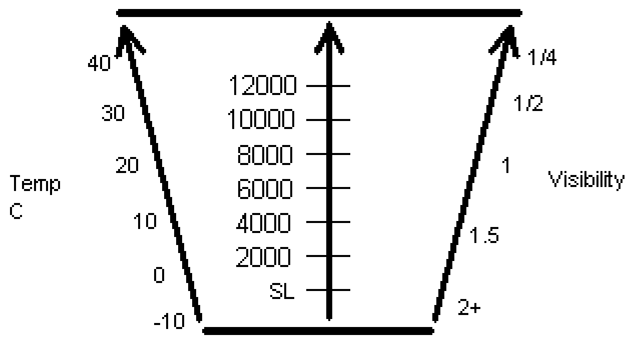
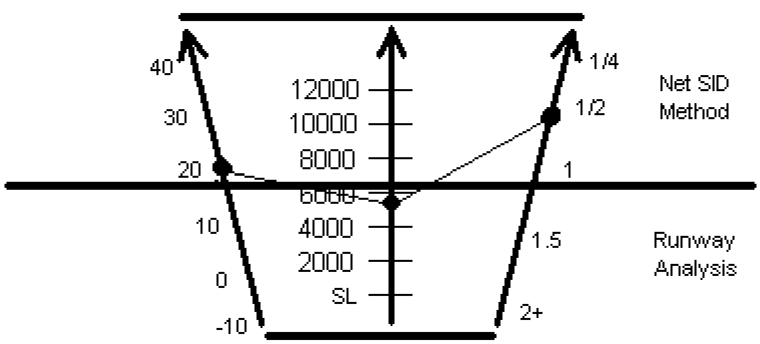


Figure G4

And operator would plot the conditions and determine which procedure to use based on an operator determined criteria.



H. Conclusion:

The goal of regulation, such as Part 135.379, is to provide obstacle clearance with adequate margins of safety, during instrument meteorological conditions, in the unlikely event an engine should fail during takeoff. The purpose of the methodology, such as described within AC120-91, is to provide a standardized approach to assure that the separation from obstacles is assured.

The Net SID methodology described above assures separation from obstacles, meeting or exceeding the limits described within 135.379 and 121.189 while on a Net Takeoff Flight Path.

Appendices

A:Advisory Circular 120-91
http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/list/AC%20120-91/$FILE/AC120-91.pdf

B: Memorandum of March 17, 2005
http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/afs420/policies_guidance/memorandums/media/Revised%20Policy%20for%20App%20of%20Vol%204,%20TERPS.pdf

C: Order 8260.3B All Changes
http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/afs420/policies_guidance/orders/