A320 SKARDU OPERATION

Last Updated: 25th May 2025

DEPARTURE TO SKARDU

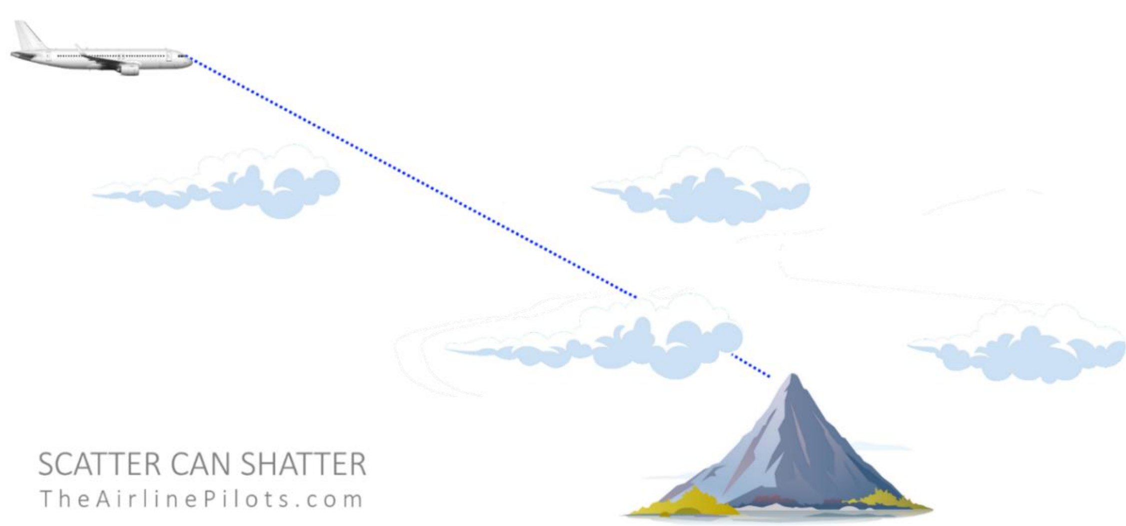
PREFLIGHT

1. Prerequisites:
    - Man:
        - Last flight > 3 months: 1 observation flight recommended (for low-time pilots).
        - Last flight > 6 months: 1 training flight recommended (for low-time pilots).
    - Machine:
        - APU: Serviceable if ground support at Skardu is not available. If unserviceable then both engine bleeds must be serviceable (to have at least two bleeds available all the time).
        - Packs: Both shall be serviceable.
        - Engine / Wing anti-ice valve: Shall not be CF in open position.
        - RW14L in use: Max landing weight 65.3 tons due PCN limits along with all narrow runway limitations.
    - Environment:
        - Weather.

2. Skardu Weather:
    - Resources:
        - METAR: From Pakistan Meteorological Department website https://rmcpunjab.pmd.gov.pk/rmclhr/asppages/selectMetar.asp

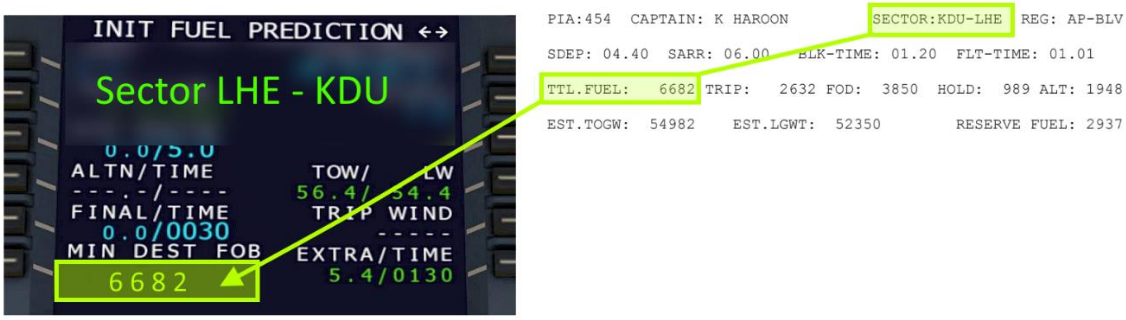
        - Satellite Pictures:
            - SKYVECTOR: https://skyvector.com
            - Weather Underground: https://www.wunderground.com/wundermap

        - Live video and images (valley and overhead clouds):
            - Skardu Tower: WhatsApp.
    - Benchmarks:
        - Visibility: 6 KM or above.
        - Cloud Cover: 3-4 oktas (Scattered) to a maximum of 4-5 oktas (Partly Cloudy).
        - Cloud Layers: Note levels and location to visualize staggering for descent planning.



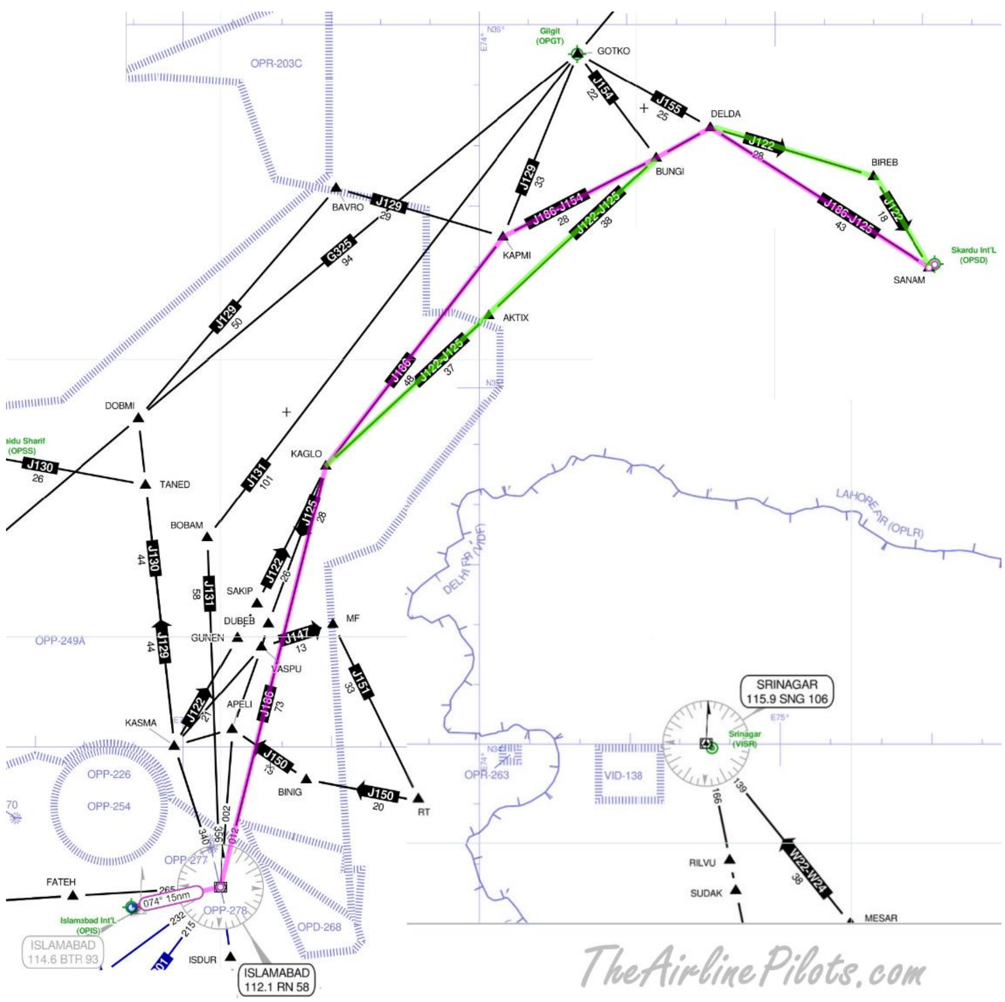
3. FMC Considerations:

- Fuel: Add next sector (KDU-XXX) fuel as reserve fuel if refueling is not available in Skardu.

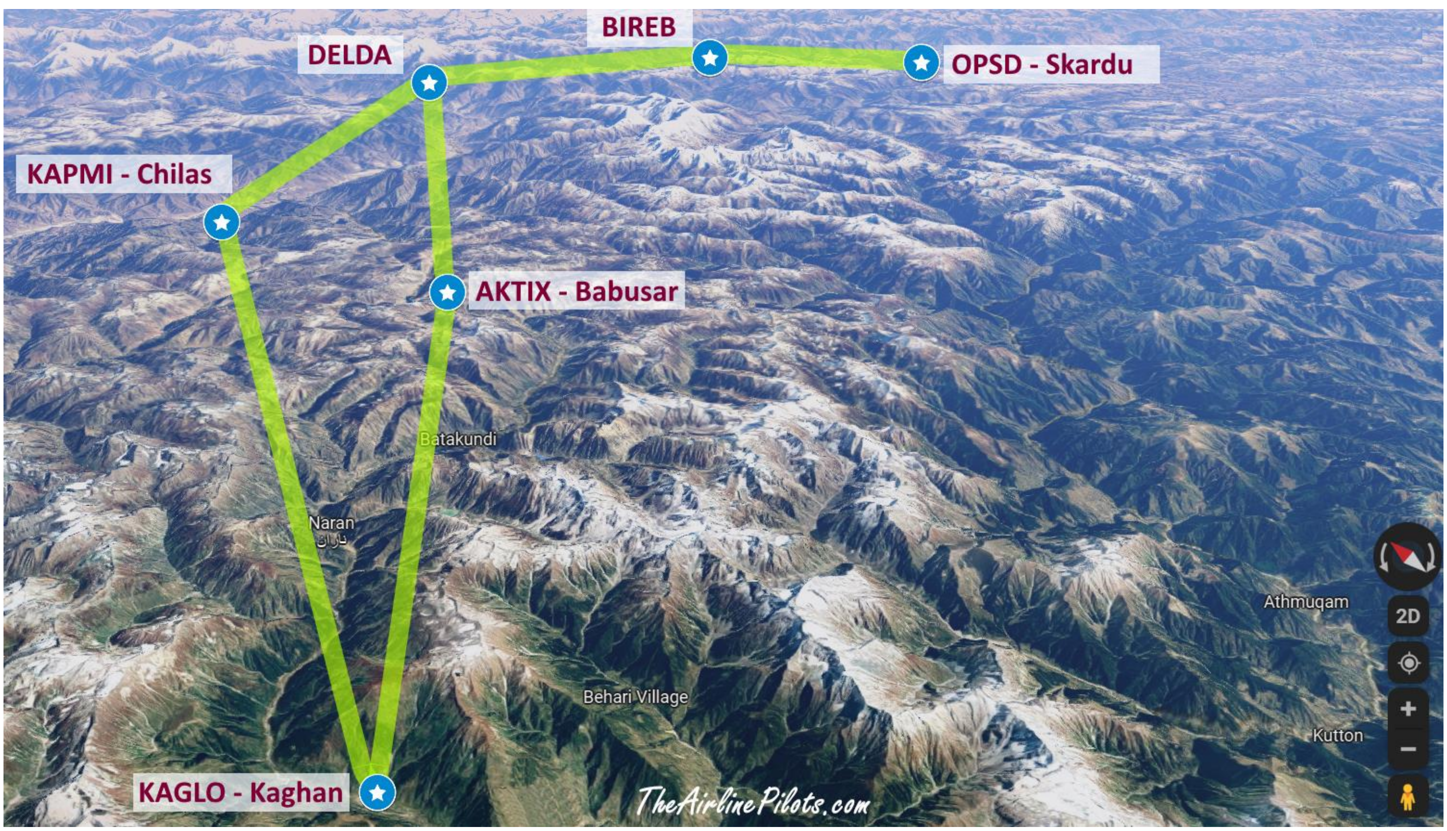


- Speed / Height constraints for descent:
  - DELDA (N3543.0 E07447.0) – Speed 220 kts.
  - BIREB (N3535.0 E07520.0) – Height 21,500 feet.
  - SD/SANAM (N3519.9 E07531.3) – Speed 170, Height 15,500.
- Route Modifications:
  - Add a waypoint 4NM before BIREB.
  - Add a waypoint 0.1NM before CF RW14.
  - Add a 5NM leg from SD on a Track of 089°.

IFR ROUTING: J186 / J122



VFR ROUTE – KAGLO TO SKARDU



VFR ROUTE – KAGLO (KAGHAN) TO KAPMI (CHILAS) OR AKTIX (BABUSAR)

VFR ROUTE – KAPMI (CHILAS) OR AKTIX (BABUSAR) TO DELDA

VFR ROUTE – BUNGI TO DELDA

ENROUTE CRUISE LEVELS

- Minimum Level: From KAGLO to DELDA the highest peak closed to the route is Malika Parbat which is approx. 17,350 feet located 10nm east-northeast of KAGLO. Average height for rest of the terrain is approx. around 14,500 feet. Giving due consideration to pressure altimeter errors and 2,000 feet clearance to Malika Parbat, FL195 and FL205 should be considered as minimum northeast and southwest levels on this route.

- Recommended Level: Ideal level after KAGLO is the one that keeps you below the cloud layers. Considering the flight time from your departure airport to Skardu, you will be much higher than your minimum safe level on this route. In case of stratus cloud layers covering the area after KAGLO, it is recommended to stay below the layers so that you have the terrain in view all the time to cater for an unrestricted descent. This has an advantage over the option of flying IFR till KAPMI (Chilas) and then changing to VFR. Cloud coverage is sometimes so extensive that if you are not VFR early enough for your descent, you might not be able to find the opportunity later to switch from IFR to VFR and therefore will have no choice but to divert back. Considering the terrain after DELDA and the descent phase, FL215 is the lowest recommended after KAGLO as this can be maintained right up till BIREB from where you can start your final descent to Skardu.

- Engine Inoperative Ceiling: Determine in cruise to facilitate effective planning.

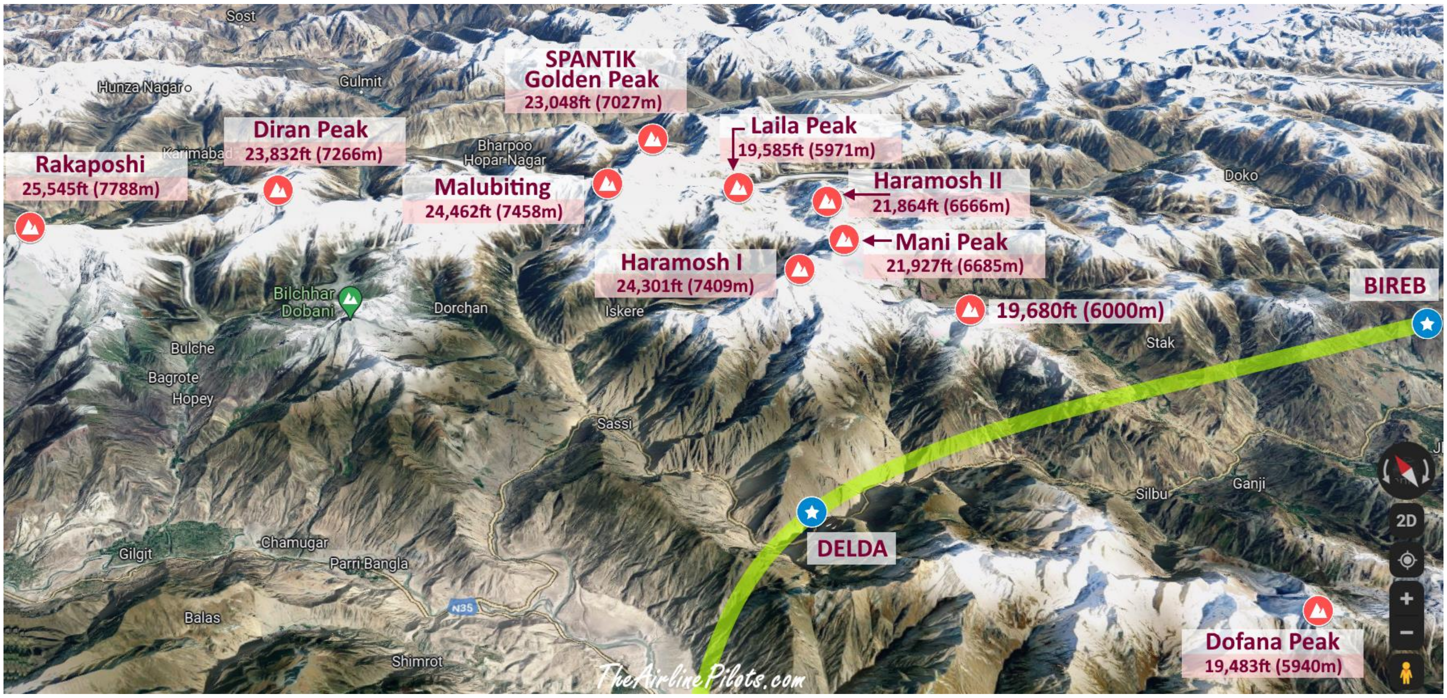
ENROUTE COMMUNICATION – KAGLO ONWARDS

- VHF1 – Standard ATC communication.
- VHF2 – Standard guard frequency monitoring on 121.5.
- VHF3 – Position reporting to all northern area traffic on 123.4.
- HF1 – Position reporting to Skardu on 5601.

DESCENT

There are two descent phases involved in this flight. Phase 1 is before DELDA while phase 2 is after DELDA. On the basis of terrain clearance, the first phase before DELDA is less critical as compared to the second phase after DELDA. Therefore, manage workload accordingly so that flying and terrain clearance has priority over other tasks during the critical descent phase.

Normally Islamabad control gives you descent up till FL215 and expects further clearance by Skardu on HF due to lack of VHF coverage. Sometimes HF reception is also poor and you are unable to get further clearance. This delay in descent clearance positions you high on your descent profile. In order to avoid this situation, request Islamabad control to coordinate with Skardu and give you unrestricted descent, so that you can continue your descent even if not in contact with Skardu.



Be wary of your speed while maintaining the descent profile. You must reduce speed before DELDA to reduce the radius of turn as there are some very high peaks north of DELDA e.g., Haramosh peak which is approx. 24,300 feet is just 8nm north of DELDA as shown in the image above.

- **DESCENT BEFORE DELDA**

Five main tasks must be completed latest by DELDA. These tasks can be recalled with the ABCDE mnemonic:

- **A**PU.
- **B**riefing.
- **C**hecklist.
- **D**eceleration.
- **E**ngine Out Ceiling

(A) While descending (below FL 25), start the APU if ground support at Skardu (GPU/Start cart) is not available. If unsuccessful, try again at a lower altitude. If still unsuccessful then divert. **(B)** Brief your strategy for descent & approach and review landing & approach climb performance. **(C)** Though you typically carry out the 10,000 feet checks (Lights, Seatbelts, Nav Accuracy checks etc.) when you are 10,000 feet AGL from your destination, which will not be the case at DELDA, but nevertheless carry out the 10,000 feet checks at DELDA to reduce your workload in the upcoming critical descent phase. Carrying out the 10,000 feet checks at 15,000 feet might not hurt as much as delaying the checks (to be done exactly at 10,000 feet) and creating a distraction from the main task. **(D)** While approaching DELDA, start reducing speed to be around 220 knots at DELDA. This will keep you ready for turning back any time after DELDA by keeping your turning radius as small as possible. **(E)** Assess your engine out ceiling against your current FL to determine if diversion to ISB is feasible after DELDA.

- **DESCENT AFTER DELDA**

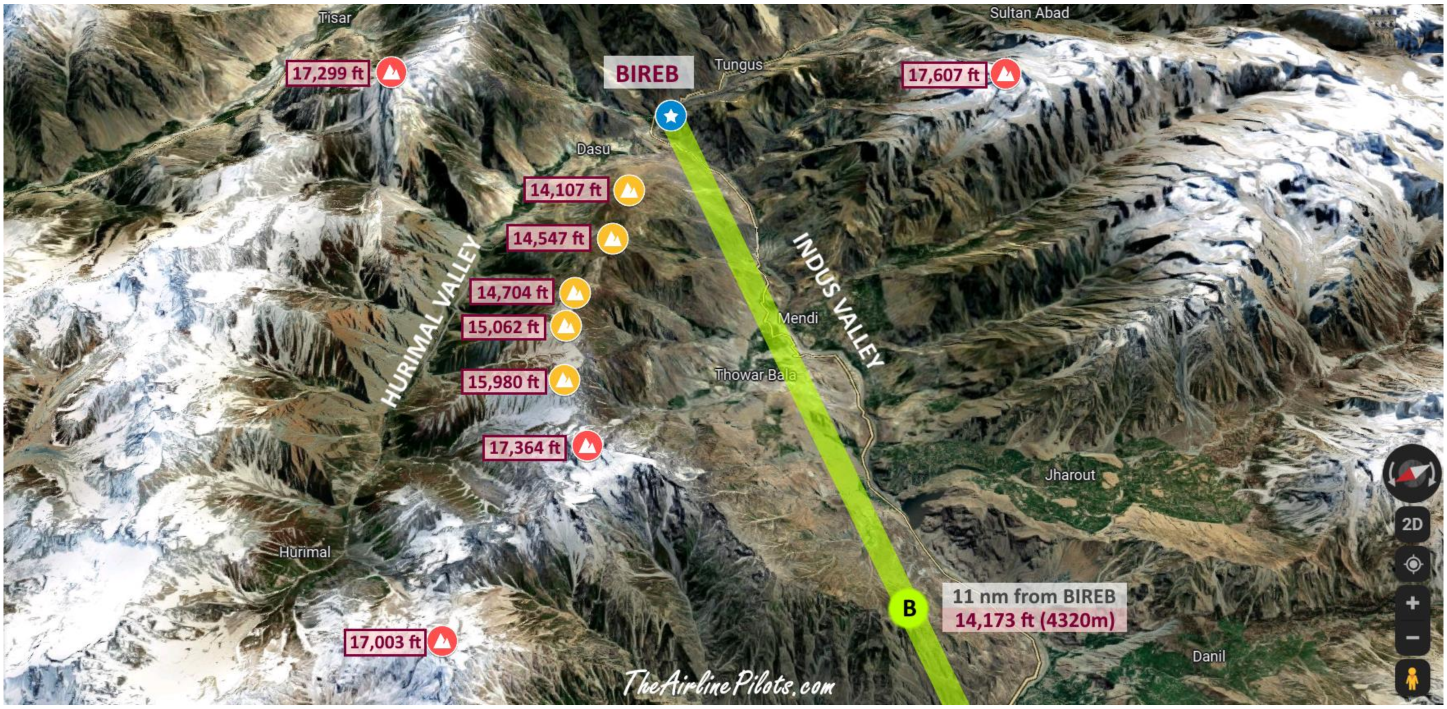
Though 250 knots IAS is not too high a speed to fly here but keep in mind that your GS will be quite high with this speed. It will of course vary with TAS and wind direction but typical figures seen after DELDA are generally around 330-345 kts. Winds from the north (typically seen around DELDA) keeps your GS under control while heading towards DELDA but same winds add a tailwind component and increase your GS while proceeding away from DELDA towards BIREB. It is recommended to keep the GS around 320-325 kts to keep your descent under control (this will be discussed later in this document). Therefore, adjust your IAS to have GS of 320-325 kts and reduce it accordingly even if it drops to the minimum clean speed.

DELDA is the point where the critical phase of this flight starts. From this point onwards you will be in your descent phase into high terrain. In order to have correct situational awareness and terrain clearance you need to have a clear idea about the terrain around you especially if you want to make a 180° turn for diversion or for side stepping into Shigar valley due to weather or conflicting traffic.

From DELDA to BIREB you will be in the Indus valley on an east-southeast heading towards Skardu. On your left (North) you will have the Haramosh peak (approx. 24,300 ft). Right (South) side will lead you to BUNGI from where you came. Highest peaks on a direct track from DELDA to BIREB are 14,777 feet (18 nm from BIREB) and 14,173 feet (11 nm from BIREB) approximately, shown in the image below as A and B respectively. That means this direct leg can easily be flown in NAV mode at FL195 all the way from DELDA to BIREB. However, there are peaks around this track which are as high as this level. About 19.5 nm short of BIREB (when you are abeam Nanga Parbat), you will have the Dofana peak (19,483 feet) on your right (South) and a peak about 19,680 feet on your left (North). In case of a significant navigational cross track error there will not be enough terrain clearance at FL195. Therefore, the recommended FL215 is the optimum level as it caters for terrain clearance on track and terrain clearance for cross track errors.

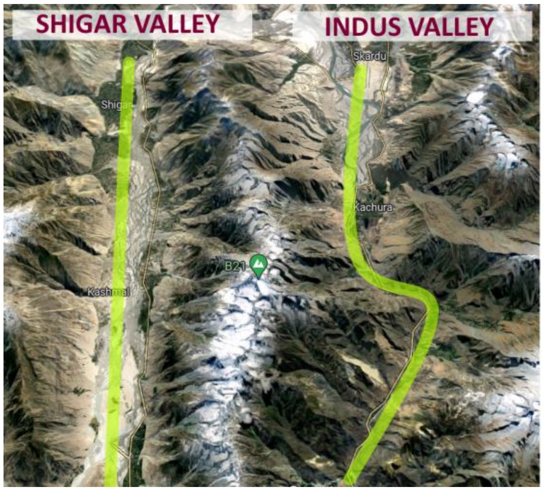
The recommendation is based on flying in NAV mode in order to pass through a transient thin layer of clouds in some emergency situations like smoke in the aircraft, uncontrollable engine fire, medical emergency etc. where one is committed to land. However, as a routine VFR flight in VMC conditions you can fly the valley in HDG mode at a lower than recommended level, instead of flying a direct track from DELDA to BIREB in the NAV mode. Depending on your height at DELDA, you can manage your descent accordingly. The minimum recommended level in this case is FL175, although in perfect VMC FL155 can also be flown.

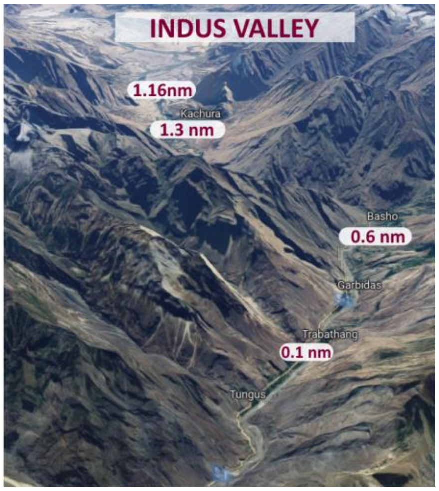
Continuing towards BIREB from point B (approx. 11 nm short of BIREB), you will be abeam the starting point of Hurimal valley on your left (North). The mountain range that separates Hurimal valley from Indus Valley starts off with peaks around 17,000 ft and ends with peaks around 14,000 ft. Hurimal and Indus valley meet at BIREB.



At BIREB you turn Southeast in the Indus valley to approach Skardu. BIREB is also the point where you are abeam the starting point of Shigar valley on your left (Northeast). Shigar valley runs Southeast to Shigar parallel to Indus valley that runs Southeast to Skardu. Both valleys meet together at the end.

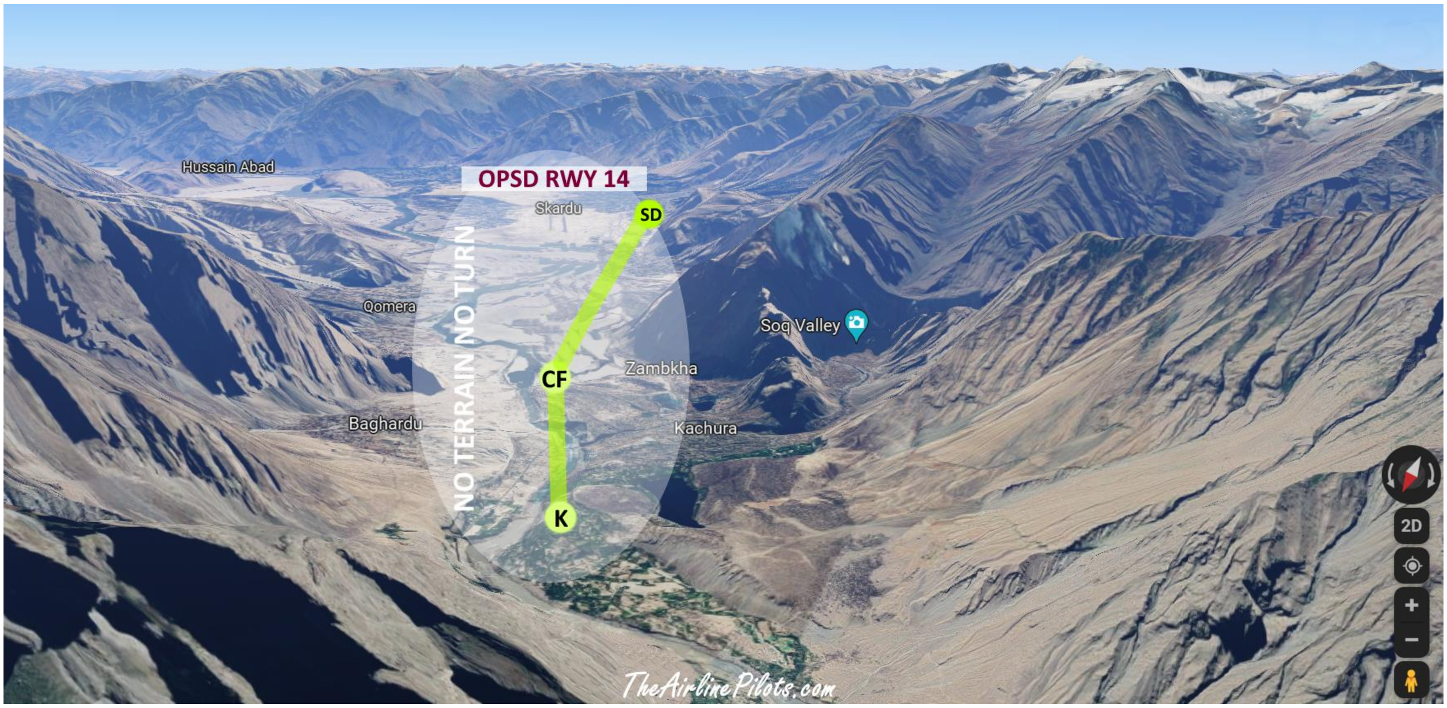
Due to conflicting traffic or weather conditions, you can sidestep from Indus into Shigar valley for approaching Skardu. Overflying Shigar, you can turn right on a westerly heading to approach Skardu. However, be wary of the high terrain that separates these two valleys. Mountain range after BIREB between Indus and Shigar valley have peaks that range from 15,000 feet to 19,000 feet approx. with B21 peak as the highest one around 19,121 feet. Therefore, if you anticipate or plan to sidestep into Shigar valley then do not descend below FL215 after DELDA – Change valleys after BIREB and then continue with your descent. Shigar valley has an advantage over Indus valley in a sense that it is wider and straighter than Indus valley which is narrower and has an “S” shaped bend in it (commonly known as the “Zulu Bend” among the local pilots). However, there are no waypoints in the navigation database that can be used for navigating the Shigar valley. Errors in creating your own waypoints inflight can have serious repercussions and is not recommended. There is no room for errors in these valleys.



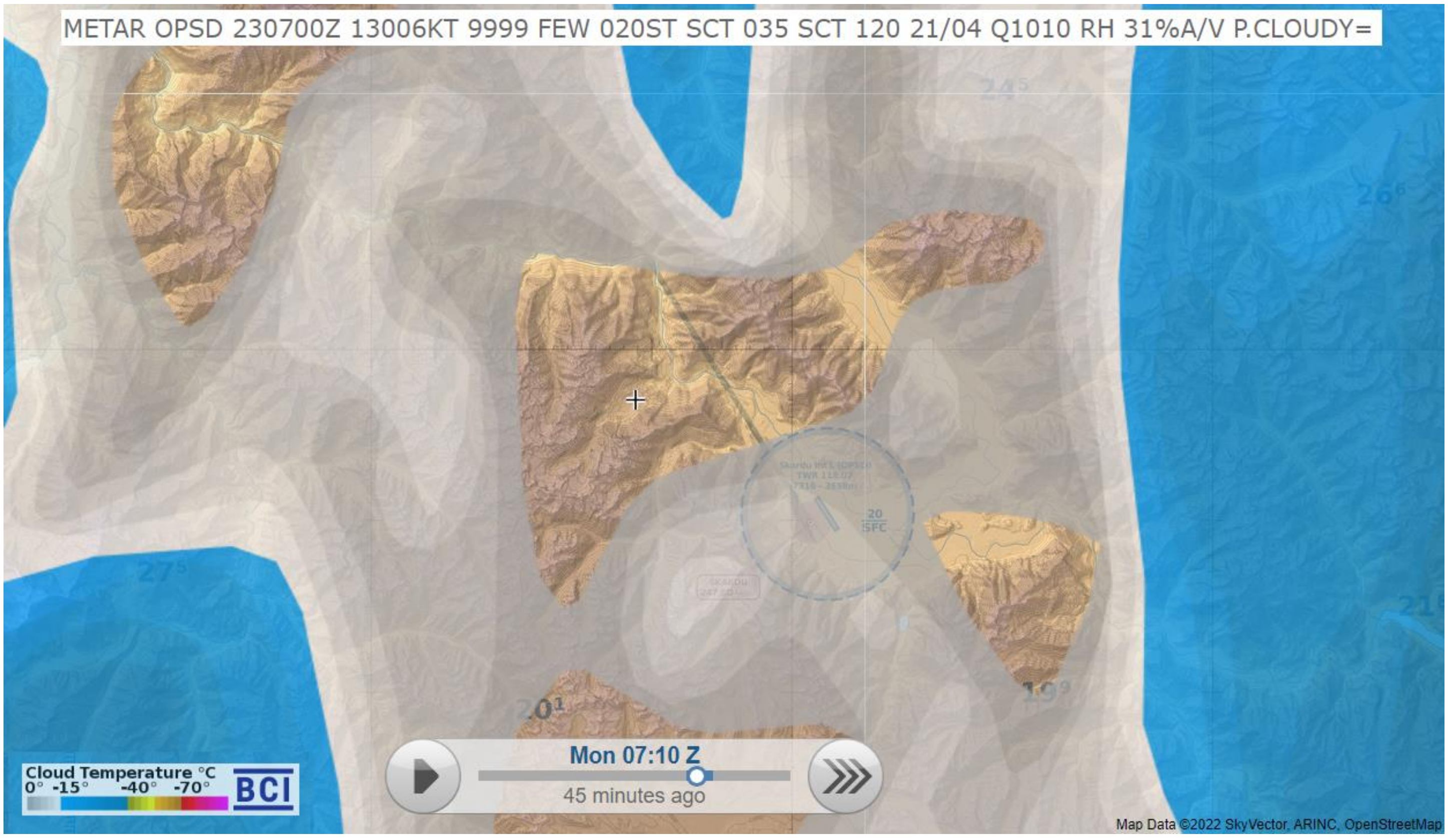


APPROACH AND LANDING

Skardu can be approached from Shigar or Indus Valley. Shigar is a straight and wide valley involving no special procedures except getting into this valley from Indus valley at a higher level due to high terrain separating the two valleys. If you are descending and approaching from Indus valley then activate approach phase and complete your approach checklist latest by position BIREB. Transition level is FL230. However, if weather conditions (restricted visibility) requires maintaining a level flight momentarily and Skardu's QNH is higher than the standard (which is common) and there is no conflicting traffic, delaying setting the QNH will provide better terrain clearance. This is because setting a higher QNH than QNE in level flight lowers the true altitude which reduces terrain clearance. Transitioning to QNH can be postponed until a safer area is reached, i.e. approx. 7nm from OPSD Runway 14 (2nm to CF RWY14, since CF is a 5nm leg). The area beyond this point is relatively free of terrain below. A visual ground reference for this is the Kachura Lake, referred to as "K" in this document.



Approach valley is not clear of clouds all the time. Often there is a stratus layer overhead Skardu. In case you are maintaining a higher level up till BIREB with Skardu airfield in sight, your preference should be to get below the layer as soon as possible in order to avoid getting stuck above the layer and losing sight of the airfield.



Normally (in perfect VMC conditions which may not be the case every time) you start reducing your speed to be at the approach speed by position BIREB. The main purpose for speed reduction is to reduce the radius of turn due to terrain. However, if turning is not a factor then increasing the speed a little bit to adjust for your descent profile will not jeopardize safety. Therefore, in case of a cloud layer over approach valley and Skardu, prefer a steeper descent angle over speed reduction as turning is not factor in this case. Increasing speed and getting below the layer will be more rewarding than reducing speed, decreasing your rate of descent and end up getting stuck above the cloud layer. Speed up till 250 knots in a clean configuration is easily manageable until approaching Skardu where you can level off and reduce to the desired F speed (using speed brakes or gears to increase deceleration if required) for further maneuvers. Reducing to green dot speed earlier than required will give you the least rate of descent as this is your best L/D speed. Taking speed brakes while descending on green dot speed to increase your rate of descent will increase your VLS rapidly. Flaps 1 will restrict your speed to its placard limit of 230 knots and will not allow further pitching down which is sometimes required to stay below the clouds. All these factors have to be considered along with weather conditions to decide which speed and profile would be the most optimum. So be flexible and fly an approach that is pragmatic and not dogmatic.

By position BIREB you will also be in VHF range so you can contact tower on 118.075 for further clearance.

The descent strategy after BIREB depends upon your height over BIREB. Since we were discussing the advantages of FL215 up till BIREB, we will now discuss the descent strategy assuming our level to be FL215 and assuming that we have to pass through a transient thin layer of clouds (that blocks the VMC view momentarily) in some emergency situation like smoke in the aircraft, uncontrollable engine fire, medical emergency etc. where one is committed to land.

Normal routing to OPSD is from BIREB, but if you turn 4nm short of BIREB and proceed directly to CF RWY14 then you have more terrain clearance. However, proceeding directly to CF RWY14 will sequence your destination and your flight plan will be erased. To get the final leg of the approach along with its descent guidance, destination can be reinserted by creating a new active flight plan or by activating the secondary flight plan if it had a copy of the original plan but this involves heads down activity during approach which should be avoided. In order to prevent the flight plan from getting erased it is recommended to keep the discontinuity before CF RWY14. To achieve this, create a point 0.1NM (or earlier) before CF and connect it to SD or SANAM while keeping the discontinuity.

Depending on the FMS type installed on the aircraft some would allow while some would not allow creating a point from CF in the typical way like CF/-0.1 so you might have to use the point BIREB for this. There can be two methods:

1. BIREB / DISTANCE
2. BIREB / BEARING /DISTANCE

Distance between BIREB and CF is 12 nm. If you use the first method then BIREB/11.9 will be a point 0.1 nm before CF but the system does not accept this value so you will have to create a point earlier than this like e.g., 11.7. For creating a point exactly 0.1 nm from CF you will have to use the second method. The track between BIREB and CF is 141^{o} so you will enter BIREB/141/11.9 to create that point.

Plan your descent from F215 with a ground speed (GS) of 320 knots and vertical speed (VS) -1800 fpm if descending from BIREB or VS -1500 fpm if descending from 4nm short of BIREB. This will bring you at 15,500 feet overhead SD. Normally the stratus layers that obstruct the ground view are around 16,000 to 17,000 feet. If you are 100% VMC at 15,500 feet, you can descent further and land otherwise climb back to FL215 and divert. Procedure after approaching SD will be discussed next but first a few words about the math involved in determining the required vertical speed while descending from FL215 to 15,500 feet and terrain clearance obtained with this descent rate.

BIREB – 1BC (0.**1** NM **B**efore **C**F) **– SD**

- Vertical Speed
  - Distance from BIREB to 1BC RWY14 = 11.9 nm.
  - Distance from 1BC to SD = 6.3 nm.
  - Total distance = 18.2 nm.
  - GS 320 knots = 5.33 nm/min (320 / 60).
  - Time from BIREB to SD = 3.41 min (18.2 / 5.33).
  - Height to lose = 21500 – 15500 = 6000 feet.
  - Gradient (6000 feet in 18.2 nm) = 5.42% or 3.1^{o}.
  - Required VS = 1760 fpm (6000 / 3.41).
  - Rounding off the VS to **1800** fpm for usability and being conservative.

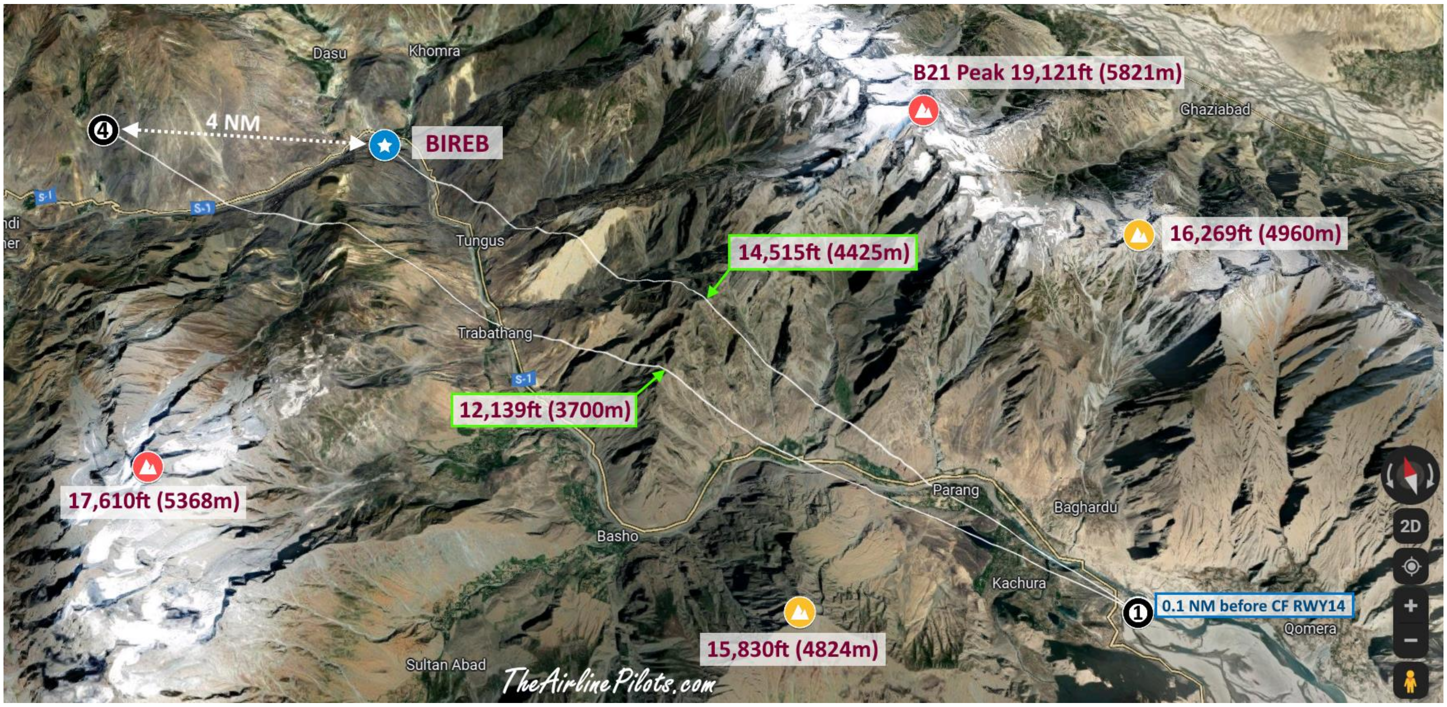
- Terrain Clearance
  - Highest peak directly under BIREB to 1BC = 14,515 feet.
  - Distance of highest peak from BIREB = 5.8 nm.
  - Time to highest peak = 1.08 min (5.8 / 5.33).
  - With VS 1800 fpm, height loss in 1.08 min = 1944 feet (1800 x 1.08).
  - Height above the highest peak on BIREB to 1BC = 19,556 feet (21,500 - 1944).
  - Clearance above the highest peak on BIREB to 1BC = **5041** feet (19,556 – 14,515).

4BB (**4** NM **B**efore **B**IREB) **– 1BC – SD**

- Vertical Speed
  - Distance from 4BB to 1BC = 15.4 nm.
  - Distance from 1BC to SD = 6.3 nm.
  - Total distance = 21.7 nm.
  - GS 320 knots = 5.33 nm/min (320 / 60).
  - Time from 4BB to SD = 4.07 min (21.7 / 5.33).
  - Height to lose = 21500 – 15500 = 6000 feet.
  - Gradient (6000 feet in 21.7 nm) = 4.5% or 2.59^{o}.
  - Required VS = 1474 fpm (6000 / 4.07).
  - Rounding off the VS to **1500** fpm for usability and being conservative.

- Terrain Clearance
  - Highest peak directly under 4BB to 1BC = 12,139 feet.
  - Distance of highest peak from 4BB = 9.1 nm.
  - Time to highest peak = 1.7 min (9.1 / 5.33).
  - With VS 1500 fpm, height loss in 1.7 min = 2550 feet (1500 x 1.7).
  - Height above the highest peak on 4BB to 1BC = 18,950 feet (21,500 - 2550).
  - Clearance above the highest peak on 4BB to 1BC = **6811** feet (18,950 – 12,139).

Following images show the terrain clearance (calculated above) over the Zulu bend.



Following Images show how terrain clearance appears visually when you fly the above-mentioned descent profile over the Zulu bend.

As mentioned earlier, from Katchura lake (K) onwards towards OPSD there is no terrain. Just for interest, below is the terrain clearance at K:

BIREB to K

DATA	TERRAIN CLEARANCE
• BIREB to K Distance = 10 nm • GS 320 = 5.33 nm/min • Time to K = 1.87 min (10 / 5.33) • VS = **1800** fpm (calculated earlier)	• VS @1800 fpm, height loss in 1.87 min = 3366 feet (1800 x 1.87) • Height above K = 18,134 feet (21500 - 3366) • Elevation of K is approx. 7700 feet at this point • Clearance above K = **10,434** feet (18,134 – 7700)

4BB to K

DATA	TERRAIN CLEARANCE
• BIREB to K Distance = 13.5 nm • GS 320 = 5.33 nm/min • Time to K = 2.53 min (13.5 / 5.33) • VS = **1500** fpm (calculated earlier)	• VS @1500 fpm, height loss in 2.53 min = 3795 feet (1500 x 2.53) • Height above K = 17,705 feet (21500 - 3795) • Elevation of K is approx. 7487 feet at this point • Clearance above K = **10,218** feet (17,705 – 7487)

Therefore, the above-mentioned descent profile which we have discussed in detail would give you a safe terrain clearance in all respect. However, be careful about VS and GS relation. If you are planning your descent at GS320 then make sure it remains 320 by altering your indicated speed else VS will have to be altered to achieve the desired target i.e., to be FL155 over SD in this case.

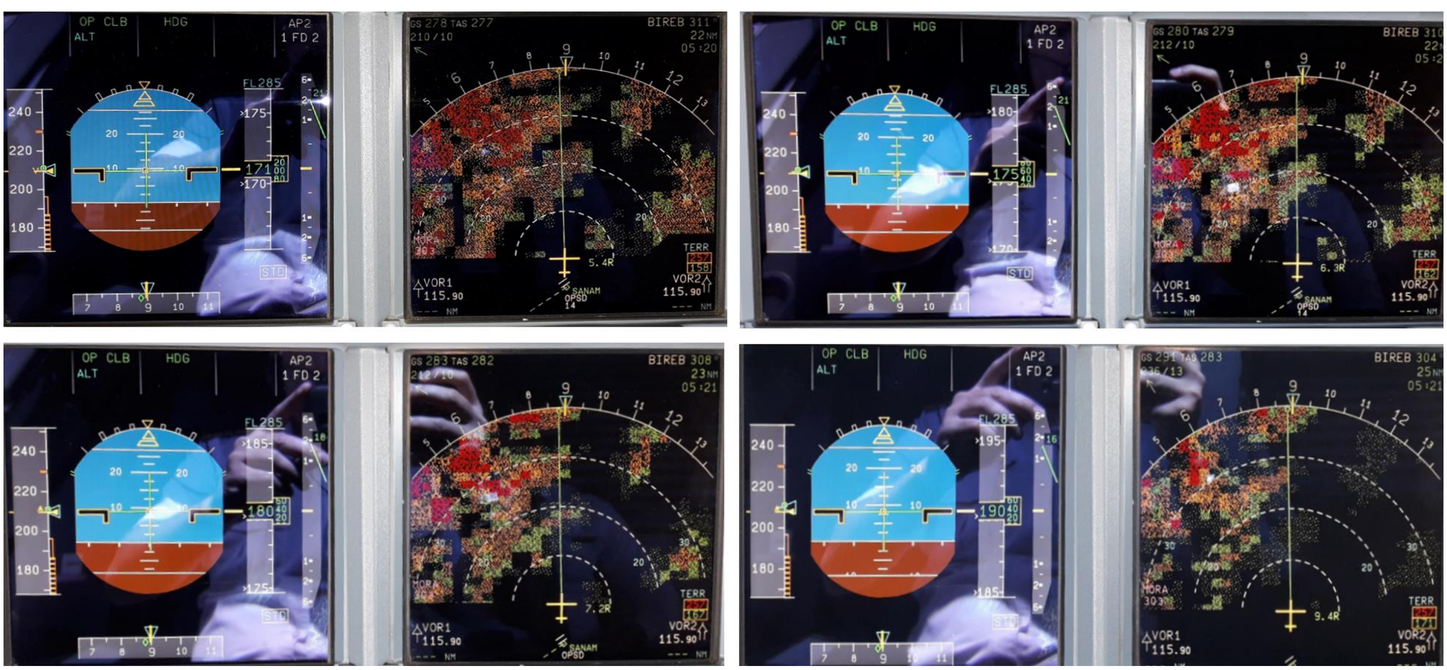
APPROACHING SD:

- Level off.
- Flaps – Flaps 1
- Speed – F or Green Dot (as required).

After crossing SD, you can discontinue approach and divert or continue to land.

DISCONTINUING APPROACH AFTER CROSSING SD:

- Track 089° towards 2nd kidney hill
  - *For initial turn, NAV mode will prevent overshooting SD and will keep you in center of the valley.*
- Select Open Climb to FL225 or higher.
- Climb at green dot speed and retract flaps.
- Check gears up and speed brakes retracted.
- After FL175 turn right towards SD. Due poor climb performance you can also enter the "TASU Valley" located south-east of the 3rd kidney hill (as shown in the image below) to gain height.
- Proceed via Indus or Shigar valley as required.
- Above procedure is based on discontinuing at 15,500 feet. If altitude is significantly lower, you might have to orbit in the valley for height before setting course. See go around procedure for additional info.



CONTINUING TO LAND AFTER CROSSING SD:

- Adjust HDG/TRK as required to keep you between kidney hills and terrain on your right.

- Select Flaps 2 and Speed 160-170 knots. Without a significant wind factor, this speed is sufficient for safely orbiting or turning in the Skardu valley.
- Select Open Descent to 9300 feet (required for left downwind RWY 14). If required to increase the rate of descent, select gears down or extend speed brakes.
- Height to lose = 6200 feet (15,500 - 9300).
- Without a significant wind factor, lose 3000 feet on your easterly heading and at 12,500 feet (15,500 - 3000) make a 180º turn towards SD and lose the remaining 3000 feet so that you are 9300 feet on downwind.

- However, while descending to 9,300 feet make sure to clear the kidney hills with sufficient margin. Level off momentarily if you think you will be too close to them. Heights of 1st, 2nd and 3rd kidney hills are 8780 feet, 9292 feet and 10,410 feet respectively. Turning back to SD at 12,500 feet would safely clear all hills.

- Join left downwind RWY14 at 9300 feet, select gears down and flaps 3. Fly the F speed.

- Approaching the end of downwind i.e., abeam the end of the ridge on your right-hand side.
    - Turn right 330 º towards Qomera village, then further right approx. HDG 350º when clear of the ridge.
    - Flaps full if priority is lowest speed. Apart from a shorter landing distance, this also prevents larger bank angles sometimes required to avoid overshooting the runway centerline — a common issue when there is a tailwind during the base-to-final turn. Otherwise flaps 3 landing has advantage during a go-around.
    - VS-700 fpm.
    - Landing Checklist.

- Approaching Qomera village:
  - AP OFF
  - FDs OFF
  - Bird ON

- Over Qomera village: Turn left for finals with a bank angle of 30º and tail of the bird on the horizon.

- Roll out on finals so that you are close to 8300 feet. Minimum is 8300 feet (1000 feet AGL).

- Runway 14R & 14L – 145º at 7301 feet elevation. Runway 32 not used due terrain constraints.
  - 14R
    - 11,994 x 147 feet.
    - PCN 50/F/C/X/T. Not weight limited.
  - 14L (145º) at 7301 feet.
    - 11,999 x 98 feet (30m) – Narrow runway.
    - PCN 40/R/C/X/T (Bitumen). Limited to Max 65.3 tons (including 5% overload allowance).
  - Fuel: Prior coordination required.
  - Fire-fighting category: 6.
  - Deicing facility: Nil.
  - Flight rules: VFR day operation only.
  - Tower Frequency: VHF 118.075.

GO AROUND

- Initially maintain runway heading.
- Then turn left to track between kidney hills and terrain on the right.
- Climb to 11,500 feet and accelerate to 160-170 knots for maneuvering in the valley.
- If unable to turn due to poor climb performance, then maneuver between kidney hills rather than flying over them to keep clear of the terrain. Keep orbiting until a safe altitude is attained.
- To make a 180º turn towards SD between 1st and 2nd kidney hill (preferred choice as explained later in the document under single engine scenarios), climb to 9500 feet before initiating the turn so that the 2nd kidney hill is cleared safely in case radius of turn increases.
- To make a 180º turn towards SD between 2nd and 3rd kidney hill, climb to 10,500 feet before initiating the turn so that the 3rd kidney hill is cleared safely in case radius of turn increases.

CONTINGENCY PLANNING

Primary threats to flights over high terrain are conditions that require an immediate descent like:

- Engine Failure: Where one engine inoperative ceiling against MOCA defines the route limits.
- Pressurization Loss: Where time at MOCA against supplemental oxygen supply defines the route limits.
- Smoke or Fire in the Aircraft: Not in itself but smoke removal procedure might lead to depressurization which defines the route limits as mentioned in the loss of pressurization case.

To manage these threats, determination of an escape route is critical when flying over areas of high terrain. Escape routes are developed based on the more restrictive of the drift down or loss of pressurization scenarios. In addition to a lateral profile the escape route also requires an appropriate vertical profile that ensures:

- 14,000 feet (or 13,000 by some authorities) can be safely achieved prior to exhaustion of oxygen.
- Further descent from 14,000 (13,000) to 10,000 feet occurs within 30 minutes of oxygen exhaustion.

Oxygen Requirement

- 14 CFR 91 – §91.211 Supplemental Oxygen:
  - No person may operate a civil aircraft of U.S. registry —
    - a) At cabin pressure altitudes <u>above 12,500 feet (MSL) up to and including 14,000</u> feet (MSL) unless the required minimum flight crew is provided with and uses <u>supplemental oxygen for that part of the flight at those altitudes that is of more than 30 minutes</u> duration;
    - b) At cabin pressure altitudes above 14,000 feet (MSL) unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes; and
    - c) At cabin pressure altitudes above 15,000 feet (MSL) unless each occupant of the aircraft is provided with supplemental oxygen.
- EASA Air Ops Annex 1 to VIII – §NCC.OP.190:
  - In any other case when the pilot-in-command cannot determine how the lack of oxygen might affect all occupants on board, he/she shall ensure that:
    - a) All crew members engaged in performing duties essential to the safe operation of an aircraft in flight use <u>supplemental oxygen for any period in excess of 30 minutes</u> when the pressure altitude in the passenger compartment will be <u>between 10,000 ft and 13,000 ft</u>; and
    - b) All occupants use supplemental oxygen for any period that the pressure altitude in the passenger compartment will be above 13,000 ft.

- ICAO Annex 6 Chapter 3.4:
    - 3.4.3.6.1. A flight to be operated at flight altitudes at which the atmospheric pressure in personnel compartments will be less than 700hPa (10,000 feet) shall not be commenced unless sufficient stored breathing oxygen is carried to supply:
        a) All crew members and 10 per cent of the passengers for any period in excess of 30 minutes that the pressure in compartments occupied by them will be between 700hPa (10,000 feet) and 620hPa (13,000 feet); and

        b) The crew and passengers for any period that the atmospheric pressure in compartments occupied by them will be less than 620hPa (13,000 feet).

    - 3.4.3.6.2. A flight to be operated with a pressurized aeroplane shall not be commenced unless a sufficient quantity of stored breathing oxygen is carried to supply all the crew members and passengers, as is appropriate to the circumstances of the flight being undertaken, in the event of loss of pressurization, for any period that the atmospheric pressure in any compartment occupied by them would be less than 700hPa (above 10,000 feet). In addition, when an aeroplane is operated at flight altitudes at which the atmospheric pressure is less than 376hPa (above 25,000 feet), or which, if operated at flight altitudes at which the atmospheric pressure is more than 376hPa (below 25,000 feet) and cannot descend safely within four minutes to a flight altitude at which the atmospheric pressure is equal to 620hPa (13,000 feet), there shall be no less than a 10-minute supply for the occupants of the passenger compartment.

    - 3.4.4.2.1. All flight crew members, when engaged in performing duties essential to the safe operation of an aeroplane in flight, shall use breathing oxygen continuously whenever the circumstances prevail for which its supply has been required in 3.4.3.6.1 or 3.4.3.6.2. will readily supply oxygen upon demand.

Altimeter Corrections

Emergency altitudes must be corrected for:

Altimeter Temperature Correction Error: If the temperature is less than that of the ISA, altitude corrections must be made to ensure sufficient terrain clearance.

Altimeter Pressure Settings: If a local altimeter setting is not available and the area atmospheric pressure is less than 1013 mb, crews should be prepared to use an area altimeter setting or the lowest of the pressure settings for the route of flight.

MSA: If the strength and direction of the wind could result in the formation of mountain waves, altitude corrections to compensate for potential wave action should be made to the minimum safe altitudes.

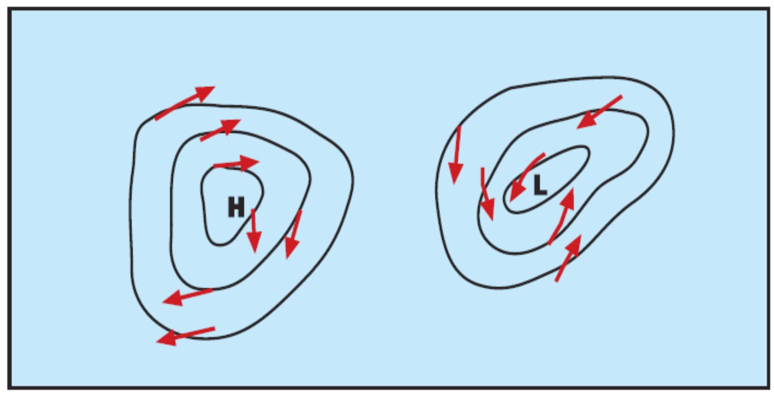
Topographical Effects on Wind (credit: navcanada.ca)

(a) Lee Effects

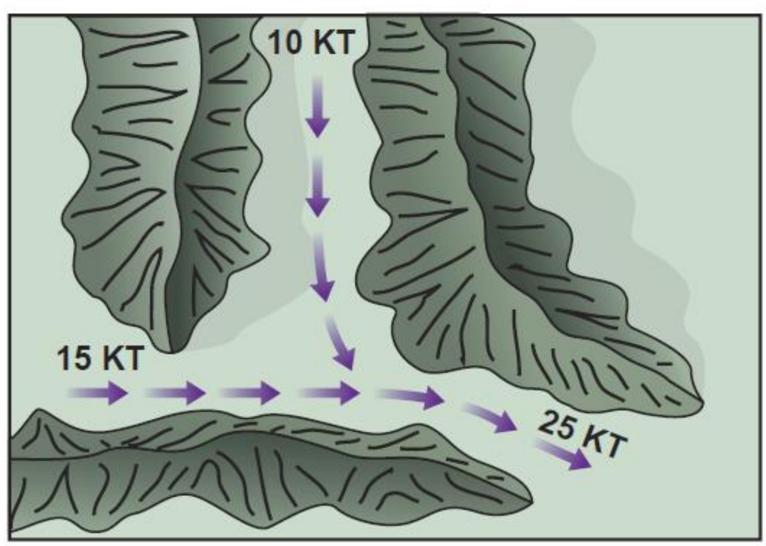
When the winds blow against a steep cliff or over rugged terrain, gusty turbulent winds result. Eddies often form downwind of the hills, which create stationary zones of stronger and lighter winds. These zones of strong winds are fairly predictable and usually persist as long as the wind direction and stability of the air stream do not change. The lighter winds, which occur in areas called wind shadows, can vary in speed and direction, particularly downwind of higher hills. In the lee of the hills, the wind is usually gusty and the wind direction is often completely opposite to the wind blowing over the top of the hills. Smaller reverse eddies may also be encountered close to the hills.

(b) Friction Effects

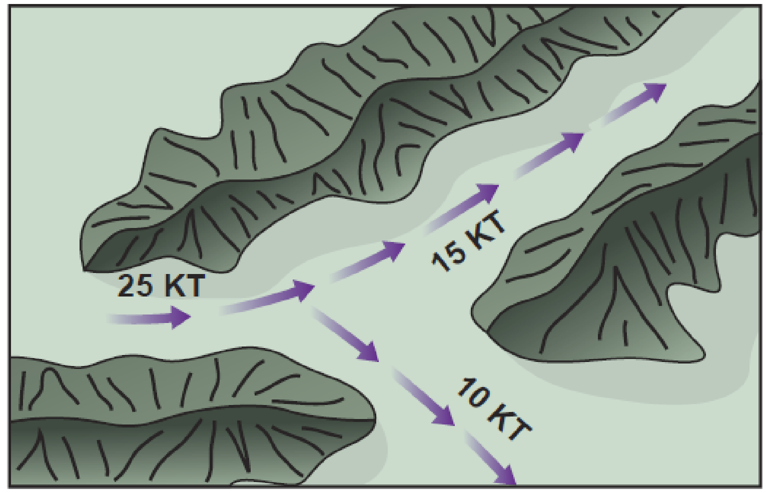
The winds that blow well above the surface of the earth are not strongly influenced by the presence of the earth itself. Closer to the earth, however, frictional effects decrease the speed of the air movement and back the wind (turns the wind direction counter-clockwise) towards the lower pressure. For example, in the northern hemisphere, a southerly wind becomes more southeasterly when blowing over rougher ground. There can be a significant reduction in the wind speed over a rough terrain when compared to the wind produced by the same pressure gradient over a relatively smooth prairie.



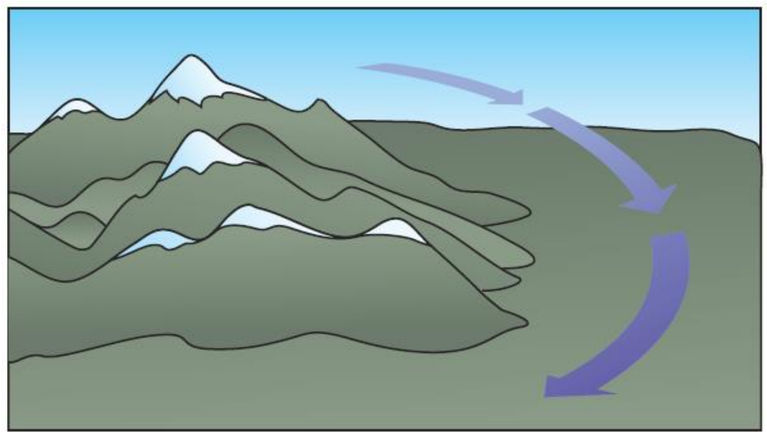
(c) Converging Winds When two or more winds flow together or converge, a stronger wind is created. Similar effects can be noted where two or more valleys come together.



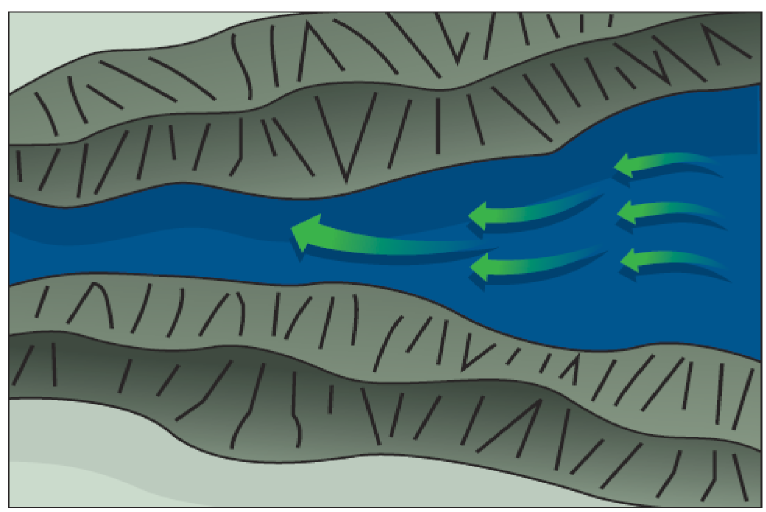
(d) Diverging Winds A divergence of the air stream occurs when a single air stream splits into two or more streams. Each will have a lower speed than the parent air stream.



(e) Corner Winds When the prevailing wind encounters a headland, there is a tendency for the wind to curl around the feature. This change in direction, if done abruptly, can result in turbulence.

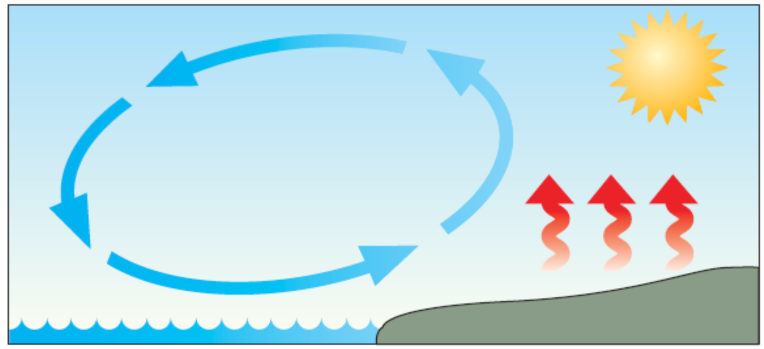


(f) Funnelled or Gap Winds When winds are forced to flow through a narrow opening or gap, such as an inlet or narrow section of a pass, the wind speed will increase and may even double in strength. This effect is similar to pinching a water hose and is called funnelling.

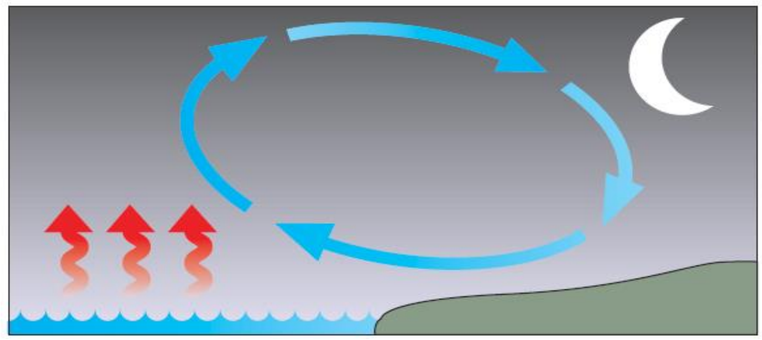


(g) Channelled Winds The topography can also change the direction of the winds by forcing the flow along the direction of a pass or valley. This is referred to as channelling.

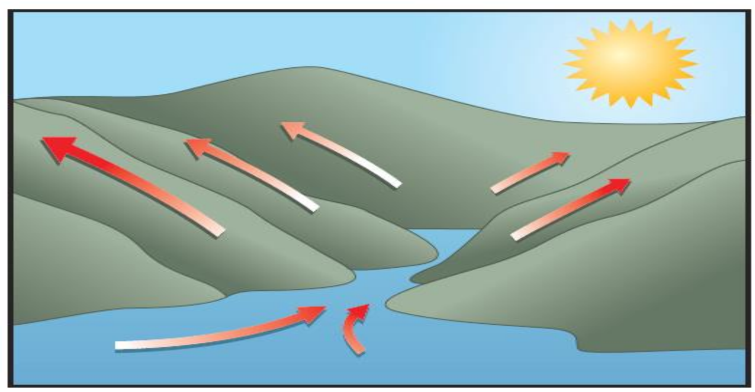
(h) Sea and Land Breezes Sea and land breezes are only observed under light wind conditions and depend on temperature differences between adjoining regions. A sea breeze occurs when the air over the land is heated more rapidly than the air over the adjacent water surface. As a result, the warmer air rises and the relatively cool air from the water flows onshore to replace it. By late afternoon, the time of maximum heating, the sea breeze circulation may be 1,500 to 3,000 feet deep, have obtained speeds of 10 to 15 knots and extend as far as 50 nautical miles inland.



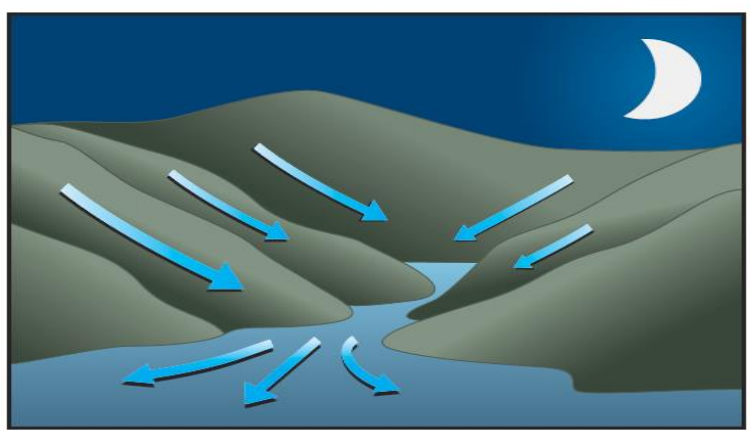
During the evening the sea breeze subsides. At night, as the land cools, a land breeze develops in the opposite direction and flows from the land out over the water. It is generally not as strong as the sea breeze, but at times it can be quite gusty. Both land and sea breezes can be influenced by channelling and funnelling resulting in almost frontal-like conditions, with sudden wind shifts and gusty winds that may reach up to 50 knots.



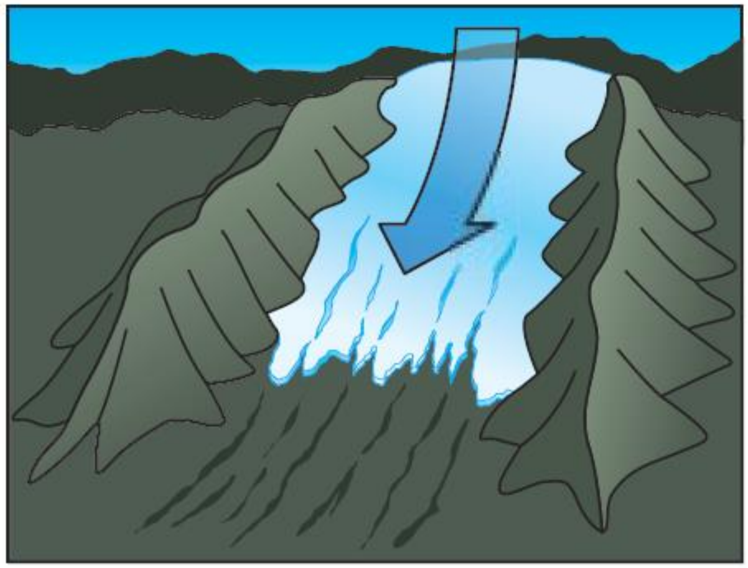
(i) Anabatic and Katabatic Winds During the day, the sides of the valleys become warmer than the valley bottoms since they are better exposed to the sun. As a result, the winds blow up the slope. These daytime, upslope winds are called anabatic winds. Gently sloped valley sides, especially those facing south, are more efficiently heated than those of a steep, narrow valley. As a result, valley breezes will be stronger in the wider valleys. An anabatic wind, if extended to sufficient height, will produce cloud. In addition, such a wind offers additional lift to aircraft.



At night, the air cools over the mountain slopes and sinks to the valley floor. If the valley floor is sloping, the winds will move along the valley towards lower ground. The cool night winds are called drainage winds, or katabatic winds, and are often quite gusty and usually stronger than anabatic winds. Some valley airports have windsocks situated at various locations along their runways to show the changeable conditions due to the katabatic flow.



(j) Glacier Winds Under extreme cooling conditions, such as an underlying ice cover, the katabatic winds can develop to hazardous proportions. As the ice is providing the cooling, a shallow wind of 80 knots or more can form and will persist during the day and night. In some locations the katabatic flow "pulsates" with the cold air building up to some critical value before being released to rush downslope.

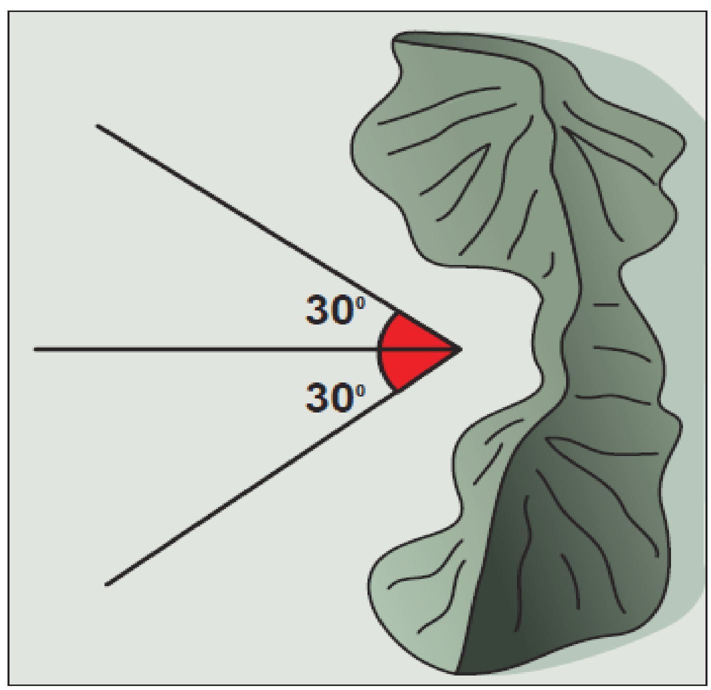


It is important to recognize that combinations of these effects can operate at any given time. Katabatic winds are easily funnelled resulting in winds of unexpected directions and strengths in narrow passes. Around glaciers in the summer, wind fields can be chaotic. Katabatic winds from the top of the glacier struggle for dominance with localized convection, or anabatic winds, induced by heated rock slopes below the ice. Many sightseeing pilots prefer to avoid glaciated areas during the afternoon hours.

Lee Waves When air flows across a mountain or hill, it is disturbed the same way as water flowing over a rock. The air initially is displaced upwards across the mountain, dips sharply on the lee side, then rises and falls in a series of waves downstream. These waves are called "mountain waves" or "lee waves" and are most notable for their turbulence. They can develop on the lee side of the mountains of Ellesmere Island and the mountain along the east side of Baffin Island.

The Formation of Lee Waves The development of lee waves requires that several conditions be met:

(a) the wind direction must be within 30 degrees of perpendicular to the mountain or hill. The greater the height of the mountain and the sharper the drop off to the lee side, the more extensive the induced oscillations.



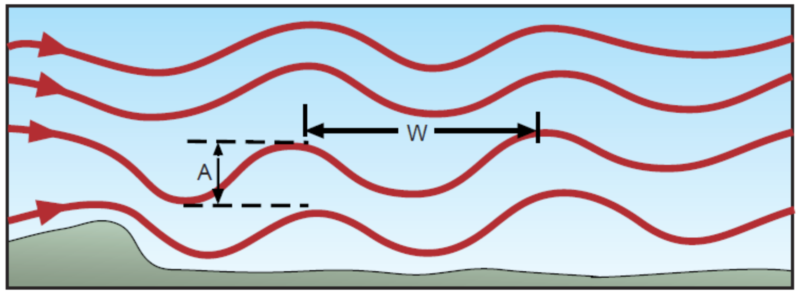
(b) wind speed should exceed 15 knots for small hills and 30 knots for mountain ridges. A jet stream with its associated strong winds below the jet axis is an ideal situation.

(c) the wind direction should be constant while increasing in speed with height throughout the troposphere.

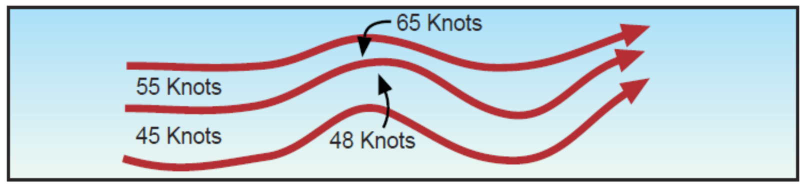
(c) the air should be stable near the mountain peaks but less stable below. The unstable layer encourages the air to ascend and the stable layer encourages the development of a downstream wave pattern.

While all these conditions can be met at any time of the year, winter wind speeds are generally stronger resulting in more dangerous lee waves.

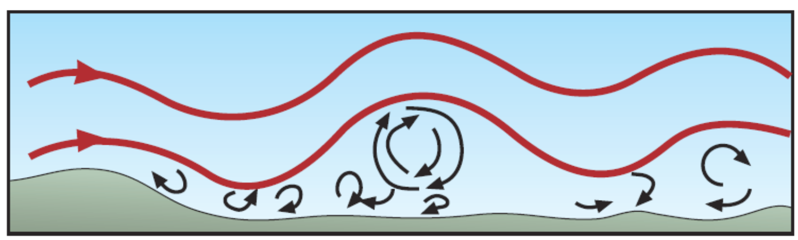
Characteristics of Lee Waves Once a lee wave pattern has been established, it follows several basic rules:



- Stronger the wind, the longer the wavelength. The typical wavelength (W) is about 6 miles but can vary from as short as 3 miles to as long as 15 miles.
- Position of the individual wave crests will remain nearly stationary with the wind blowing through them as long as the mean wind speed remains nearly constant.
- Individual wave amplitude (A) can exceed 3,000 feet.



- Layer of lee waves often extends from just below the tops of the mountains to 4,000 to 6,000 feet above the tops but can extend higher.
- Induced vertical currents within the wave can reach values of 4,500 feet per minute.
- Wind speed is stronger through the wave crest and slower through the wave trough.
- Wave closest to the obstruction will be the strongest with the waves further downstream getting progressively weaker.



- A large eddy called a “rotor” may form below each wave crest.
- Mountain ranges downstream may amplify or nullify induced wave patterns.
- **Downdrafts are frequently found on the downwind side of the obstruction**. These downdrafts typically reach **values of 2,000 feet per minute but downdrafts up to 5,000 feet per minute have been reported**. The strongest downdraft is usually found at a height near the top of the summit and **could force an aircraft into the ground**.

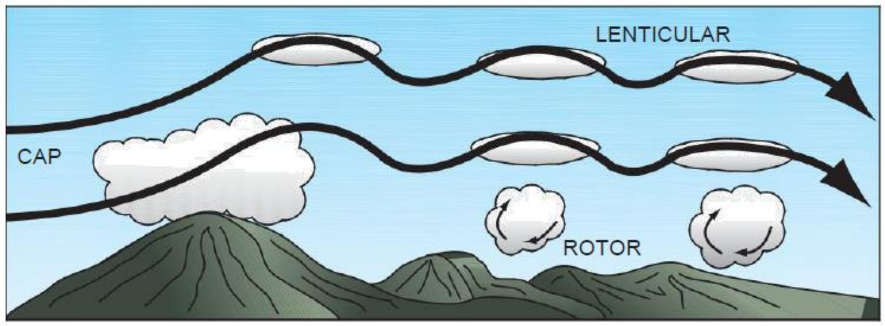
Clouds Associated with Lee Waves Lee waves involve lift and, if sufficient moisture is available, characteristic clouds will form. The signature clouds may be absent, however, due to the air being too dry or the cloud being embedded within other clouds and not visible. It is essential to realize, nevertheless, that the absence of lee wave clouds does not mean that there are no lee waves present.

(a) Cap cloud A cloud often forms over the peak of the mountain range and remains stationary. Frequently, it may have an almost “waterfall” appearance on the leeward side of the mountain. This effect is caused by subsidence and often signifies a strong downdraft just to the lee of the mountaintop.

(b) Lenticular clouds A lens shaped cloud may be found at the crest of each wave. These clouds may be separated vertically with several thousand feet between each cloud or may form so close together they resemble a "stack of plates." When air flows through the crest it is often laminar, making the cloud smooth in appearance. On occasion, when the shear results in turbulence, the lenticular cloud will take on a ragged and wind torn appearance.

Lenticular cloud at Resolute credit: David Schmidt

(c) Rotor cloud A rotor cloud may form in association with the rotor. It will appear as a long line of stratocumulus, a few miles downwind and parallel to the ridge. Its base will be normally below the peak of the ridge, but its top can extend above it. The turbulence associated with a rotor cloud is severe within and near the rotor cloud.



PRESSURIZATION FAILURE WHILE HEADING TOWARDS KDU

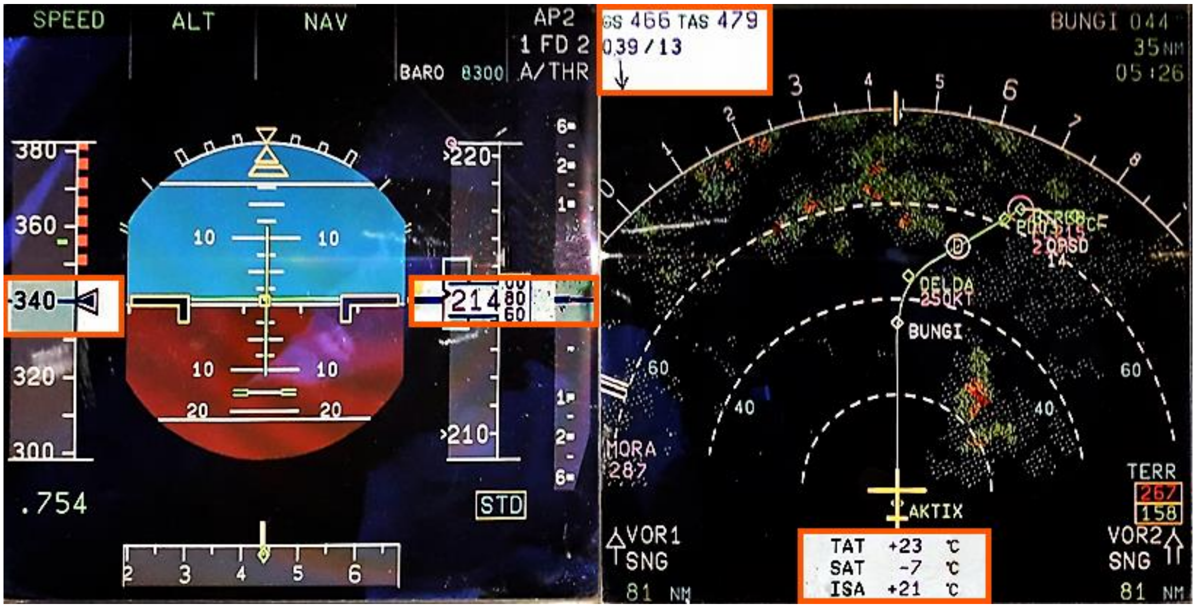
Determining mere location of the critical point (CP) for an emergency or rapid descent does not resolve all the issues. One must be sure that there are no clouds after CP that would restrict the descent into valley followed by a safe landing. In some conditions it might be safer to turn back shortly after crossing CP rather than continuing to descend in a valley full of clouds. However, to avoid turning back after crossing CP it would be more appropriate to evaluate all conditions and set the CP as close as possible to Skardu so that one has the option of turning back in case of pressurization failure rather than continuing and descend in surprising cloud conditions. Surprising in a sense that it is very rare to have perfect VMC conditions in the valley with no clouds at all. Actual conditions might be different than the forecasted ones and sometimes they are obscured all the way until BIREB. In case of a CP not close to Skardu e.g., CP before DELDA, one would be inclined to start the emergency/rapid descent in pressurization failure after crossing CP for obvious reasons since CP would have been crossed. In case the actual cloud conditions have not been determined or visualized correctly, there is a chance that one can get stuck in clouds with an existing malfunction creating a multiple emergency condition.

While determining the CP, three important things to consider are:

- Aircraft Performance.
- Terrain clearance.
- Oxygen capacity for crew and passengers.

Aircraft Performance

Previously we have been discussing the whole flight profile to KDU at FL215. So, let us see the performance at the same level. Below is a snapshot of a flight to KDU at FL215.



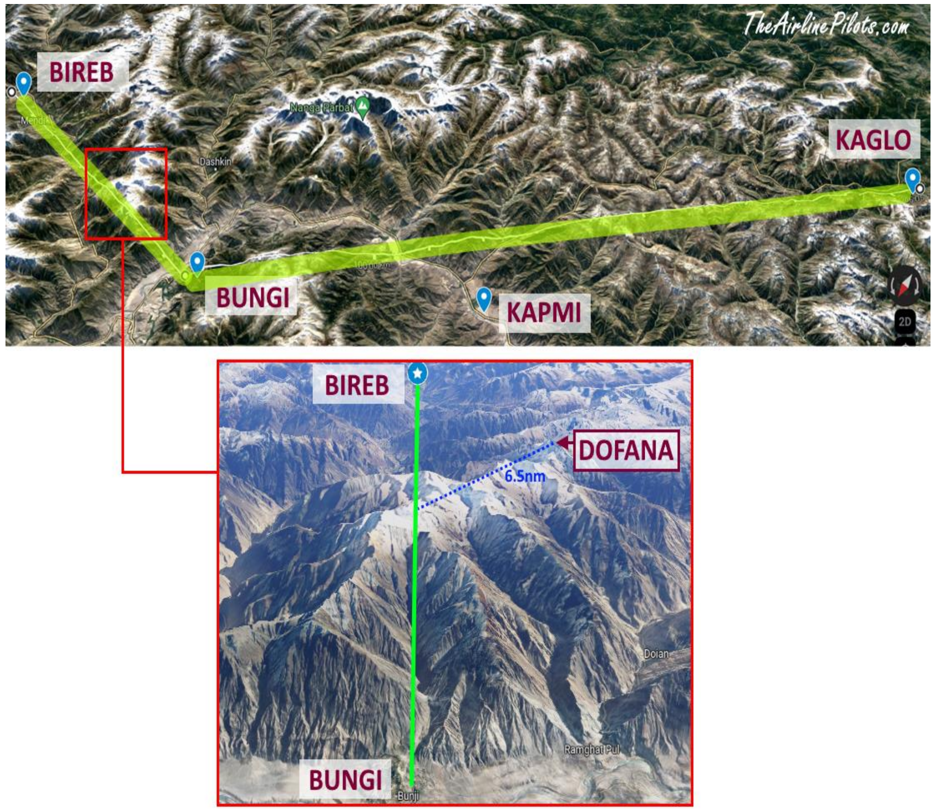
At a speed of 340 KIAS (which one would select in case of pressurization failure) the GS was 466 knots (7.7 nm/min) with a 10 knots headwind at ISA+21. Fuel flow (not shown in this image) was 4400 Kg/h. In case you are higher than FL215 you will be faster because of lesser air density. Below is a snapshot of a flight at FL 285.

At 320 KIAS the GS was 483 knots (8 nm/min) with approx 15-16 knots headwind at ISA+19. Fuel flow (not shown in this image) was 3400 Kg/h. As you can see that a higher level gives you a better performance in terms of speed and fuel. However, we'll take the lower level i.e. FL215 to have conservative calculations for determing the critical points.

Terrain Clearance

KAGLO – BUNGI – BIREB

Malika Parbat is the highest near KAGLO with a peak of 17,350 feet located 10nm East NE of KAGLO. Highest peaks on the track from KAGLO to BUNGI are approx. 15,500 feet with average heights ranging from 10,500 to 15,500 feet. The highest point on the track line from BUNGI-BIREB (red box in the image above) is approx. 13,100 feet. Even if you drift right considerably, the highest peak is Dofana at 19,483 feet located approx. 6.5 nm away from this track. This means on KAGLO-BUNGI-BIREB track, you can easily descend to or maintain 21,500 feet all the way between KAGLO and BIREB.



Oxygen Capacity

Oxygen capacity can vary across aircraft within a fleet.

<u>For Passengers</u>

- Some aircraft have a higher oxygen capacity – 22 mins (AP-BLW, BLU, BMX).
- While some have less oxygen capacity – 15 mins (other than BLW, BLU, BMX).

<u>For Flight Crew</u>

Based on minimum bottle pressure specified in FCOM limitations, after loss of cabin pressure with mask regulator on NORMAL (diluted oxygen):

- Some aircraft (AP-BLW, BLU, BMX) have a higher oxygen capacity
  - 22 mins during emergency descent.
  - 98 mins during cruise at FL100.
- While some (other than AP-BLW, BLU, BMX) have less oxygen capacity
  - 13 mins during emergency descent.
  - 107 mins during cruise at FL100.

Since passenger oxygen is generally more limited than crew oxygen, further discussion in this document on pressurization failure scenarios is based on passenger oxygen limits.

Calculations Based on Performance, O2 Capacity & Terrain

Diverting Before BIREB Back to ISB

<u>BIREB – BUNGI – KAGLO (AT FL205)</u>

- BIREB – BUNGI – KAGLO is 111 nm. At FL 205, with a GS of 7.5nm/min (see aircraft performance data above), it will take 14.8 mins to cover 111 nm. Round it off to 15 mins for being conservative.

<u>KAGLO – ISB (FROM FL205 TO 13,000 FEET)</u>

- From 20,500 (FL205) to 13,000 feet the difference is 7500 feet. With an easily achievable 4000 fpm ROD, losing 7500 ft will take 1.8 mins. Round it off to make it 2 mins for being conservative.

<u>BIREB – BUNGI – KAGLO – ISB</u>

- Total time from 20,500 to 13,000 feet = 17 mins (15 mins for BIREB-KAGLO at FL 205 and 2 mins for KAGLO-ISB from FL205 to 13,000 feet). In case you are able to descend below 20,500 to something like 16,500 in VMC then you can save a minute more (16500 – 13000 / @4000 fpm = 53 sec). If your ROD is around 6000 fpm it will take you 35 secs. So total time in this scenario can be reduced to 16 or 15.5 mins.
- In case of pressurization failure and structural damage assuming you do not accelerate to 340 knots and maintain your flight planned cruise speed that gives you a GS of 400 knots (to be conservative as generally its more than this i.e. around 430-450 knots), you will cover 6.6 nm per min. That means instead of 15 it will take 16.8 min to cover 111 nm. Increasing the total time by 2 mins means 18.8 minutes instead of 17 which is still within 22 mins i.e. well within limits of aircraft having 22 minutes of oxygen.
- Above timings do not include the course reversal time. You can add 2 minutes more to make the total time 19 mins for no structure failure case and 21 mins for structure failure case. Timings are still within 22 minutes limit. The 2 min course reversal time has been derived from actual inflight aircraft performance *(Tracking South – FL210 – Wind Westerly at 24 knots – IAS 220 – GS 290 to 310 – Right Turn – Bank 25^o with AP ON. After a 180^o turn the time was 1'52" with a lateral offset of 5.7nm. Complete 360^o turn time was 3'54" with a lateral offset of 1nm left of initial track due cross wind).*

- Considering it takes 2 mins to descend from FL205 to 13000 feet (as discussed above) the distance covered in 2 mins will be 15 nm assuming you are covering 7.5nm/min (as discussed above). KAGLO-RN-BTR = 86nm. 86 - 15 = 71nm. At 13,000 feet you will be 71nm from ISB. Even at a slow speed of 250 knots i.e., approx. 4nm/min it will take approx. 18 mins to reach ISB. That means oxygen requirement for passengers (as per regulations) is not an issue even if unable to descend below 13,000 feet all the way to ISB. Though this is unlikely as after approx. 9nm from KAGLO the terrain will allow you to descend to 10,000 feet as shown in the image below. In fact, by the time you reach 13,000 feet you will be 15nm beyond KAGLO (assuming GS is 7.5nm/min) and can continue your descend to 10,000 feet.

Above timings in various scenarios are well withing limits of aircraft having 22 minutes of oxygen but not for aircraft with 15 minutes of oxygen. For 15 minutes of oxygen, we can consider the following calculations:

<u>DELDA-BUNGI-KAGLO (AT FL205)</u>

DELDA-BUNGI-KAGLO is 85 nm. With a GS of 7.5nm/min it will take 11.3 mins to cover this distance.

<u>KAGLO – ISB (FROM FL205 TO 13,000 FEET)</u>

Based on the above discussion, it takes 2 minutes to descend from FL205 to 13,000 feet.

<u>DELDA – BUNGI – KAGLO – ISB</u>

Total time from 20,500 to 13,000 = 13.3 minutes (11.3 minutes for DELDA-KAGLO at FL 205 and 2 minutes for KAGLO-ISB from FL205 to 13,000 feet), which is within limits of aircraft having 15 minutes of oxygen.

In case of pressurization failure and structural damage assuming you maintain your flight planned cruise speed of 6.6 nm per min, it will take 12.8 mins to cover 85 nm instead of 11.3. Increasing the total time by 2 mins means 14.8 mins instead of 13.3 which is within limits of aircraft having 15 mins of oxygen but after adding 2 mins for course reversal it becomes 16.8 mins which becomes out of limit. To be within 15 mins we need to reduce 1.8 min (i.e. 16.8 - 15) to get a safe CP. Assuming we are cruising at 7.5nm/min, we will cover a distance of 13.5nm in 1.8 mins. That means 13.5nm before DELDA should be good as a CP for aircraft with 15 mins of passenger oxygen. To be further conservative make it 15nm before DELDA.

Critical Point (CP) and Strategy for Pressurization Failure

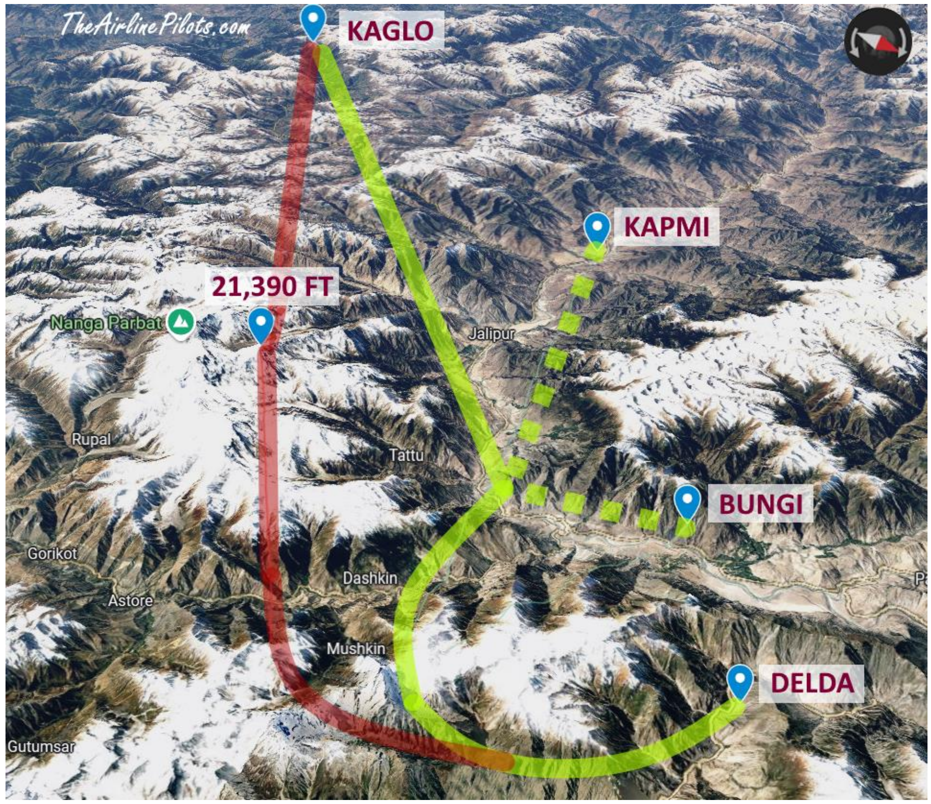
Based on the above calculations, it seems reasonable to consider BIREB and 15nm before DELDA to be the critical points based on O2 carrying capacity:

- **BIREB** – For A/C with 22 MIN Passenger Oxygen
- **15 NM before DELDA** – For A/C with 15 MIN Passenger Oxygen

- **BEFORE CP**
  - Course:
    - Course reversal to ISB.
    - Turn direction will depend on your location and height.
  - Speed:
    - Complete the turn at a slower speed.
    - Accelerate to MMO / VMO.
  - Level:
    - Up to KAGLO, FL185 - FL205. In perfect VMC, FL165 – FL185.
    - Ater KAGLO, 13,000 feet or below.
- **AFTER CP**
  - Course:
    - Continue to Skardu via Indus valley.
  - Speed:
    - Depends on the level. At lower levels like 155 you may have to reduce your speed closer to minimum clean due to tight turns in the valley.
  - Level:
    - Lowest safe level in Indus valley in perfect VMC condition is FL155.

Minimum Clean Speed for Course Reversal

Experimental Observations – In a Simulator



At position DELDA (heading towards BIREB) with an IAS of 250 (had a GS of 340 knots) at FL 215, a right turn was initiated direct to KAGLO to simulate a turn back in case of pressurization failure. It took 3 mins to complete the turn and time to KAGLO after the turn was 10 mins i.e. a total of 13 mins to KAGLO if a turn was initiated at DELDA. Time wise you could reach within 15 mins however, at this speed after completing the turn, you head towards peaks located northwest of Nanga Parbat (as shown in the image on the right), which are close to and part of the main Nanga Parbat massif, triggering GPWS warnings. Therefore, at a lower level always turn with minimum clean speed and initially plan to head towards KAPMI. Assess terrain clearance and then set course to KAGLO. A left turn to KAGLO may be possible before DELDA while heading towards it, but not after DELDA due to the conflict between the turning radius and the Haramosh range. To reduce the time for course reversal, one can disconnect the AP and turn with 30^{o} bank because AP is always seen to turn at 25^{o}.

Experimental Observations – Inflight

At position BIREB, while enroute to OPSD, a 180° turn was executed at green dot speed with the autopilot engaged. The bank angle was maintained at 25°, as is standard with AP. Upon completing the 180° turn (heading towards BUNGI), the aircraft was 5-6 NM off track from the line connecting BIREB and DELDA. In this maneuver at FL215, terrain clearance is not a concern, provided the turn is performed at green dot speed. Refer to the image on the right for further details.

Challenges of setting a CP "before but not close" to DELDA (such as KAPMI)

As a rule, there is no turning back after you cross your CP so it must be selected carefully. Factors like weather, combined with the use of an oxygen mask and wearing glasses, can pose significant hindrances and distractions. Additionally, descending to 15,500 feet to enter the valley requires a speed reduction to navigate valley turns, which further increases the time needed to descend to 13,000 feet.

KAPMI – DELDA

Let us evaluate four speed schedules to calculate the time required to travel from KAPMI to DELDA, assuming you continue to KDU after crossing KAPMI in the event of a pressurization failure.

- With a GS of 450, time will be 5 mins.
  - *450nm = 7.5nm/min. KAPMI to DELDA = 38nm. Time in mins = 38/7.5.*
- With a GS of 400, time will be 5.7 mins.
- With a GS of 350, time will be 6.5 mins.
- With a GS of 300, time will be 7.6 mins.

DELDA – BIREB – SANAM (KDU)

The straight-line distance from DELDA to BIREB (28nm), BIREB to SANAM/KDU (17nm) totals 45nm. The curved valley distance will be slightly longer.

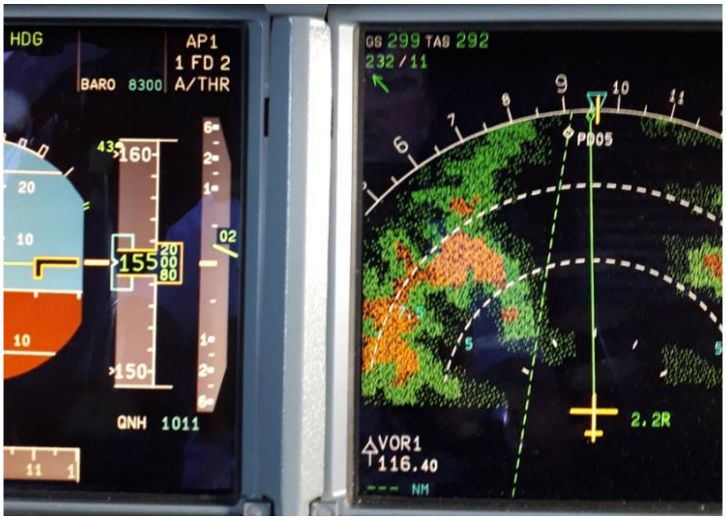
- With a GS of 300, time will be 9 mins to cover 45nm.

DELDA – BIREB – ZULU bend

The straight-line distance from DELDA to BIREB (28nm), BIREB to ZULU Bend (10nm) totals 38nm. The curved valley distance will be slightly longer. ZULU bend is considered instead of SANAM because, beyond this point, there is no terrain obstructing a descent to 13,000 feet.

- With a GS of 300, time will be 7.6 mins to cover 38nm.
- Adding an additional 1 minute to descend to 13,000 feet, the total time increases to 8.6 minutes.

Note: After DELDA, a GS of 300 knots (5 nm/min) was selected for time calculations, considering the tight turns in the valley and terrain rising above FL155. This choice was made after flying in the Indus Valley at FL155 at speeds near the minimum clean configuration. A GS of 300 knots was found to be the most suitable for low-level valley navigation.



To Summarize:

Time from KAMPI to DELDA can be:

- 5 mins @ GS 450
- 5.7 mins @ GS 400
- 6.5 mins @ GS 350
- 7.6 mins @ GS 300

Time from DELDA – ZULU Bend – 13,000 feet can be:

- 8.6 mins @ GS 300

Total Time from KAPMI to 13,000 feet based on your speed can be:

- 13.6 mins
- 14.3 mins
- 15.1 mins
- 16.2 mins

The above timings show that aircraft with 22 minutes of oxygen supply can manage without concern, but for those with only 15 minutes, it is crucial to select a speed that ensures the total time remains under 15 minutes. This requires a ground speed greater than 350 knots. Descending at a slower speed would necessitate increasing speed later in the Indus Valley to stay within the 15-minute limit, which may be undesirable due to the tight valley turns. Conversely, descending at a higher speed before DELDA would require additional time to decelerate, ensuring safe navigation of the valley turns.

Weather conditions, such as unknown patches of cloud in the valley, distraction of using an oxygen mask along with wearing glasses (if applicable), and precise speed control to manage turning radii in the valley, present some significant challenges if the CP is set much earlier than DELDA because once you cross the CP you are obliged to proceed.

ENGINE FAILURE DURING CRUISE AND CRITICAL POINT (CP)

SOME FACTORS INVOLVED IN CP DETERMINATION

1. Aircraft Performance:
    - One-engine cruise speed.
    - Fuel consumption with one engine inoperative.
    - Single engine driftdown ceiling.
2. Wind and Weather Conditions:
    - Wind speed and direction.
    - Weather of aerodromes on either side of CP.
3. Time Calculations:
    - Time to aerodromes on either side of CP.
    - ETOPS limitations if any.
5. Terrain and Obstacle Clearance:
    - Terrain along the route.
    - Obstacle clearance during single engine driftdown
        - 2000 feet clearance during driftdown
        - 1000 feet clearance on a level flight

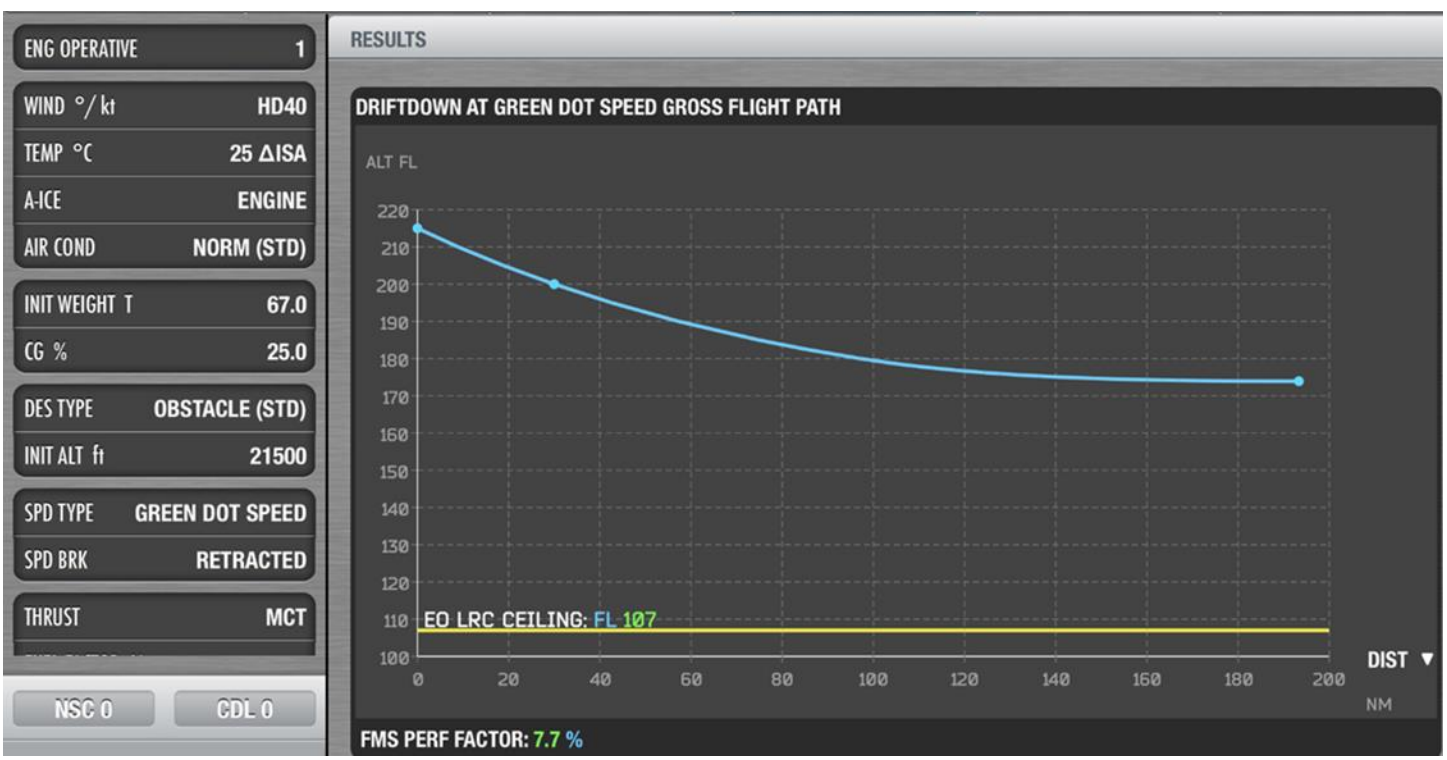
Considering DELDA as the CP

After analyzing the factors mentioned above, three key categories emerge: Aircraft Performance, Terrain Clearance, and Weather at Skardu and Islamabad, which appear to be the primary considerations when selecting a CP. Given the terrain constraints between DEDLA and Skardu, DEDLA appears to be a geographically significant point, particularly in relation to engine failure and drift-down scenarios. However, this represents only a single dimension (horizontal axis). Your flight level plays a critical role when evaluating DELDA as the CP. At a higher FL, it may be feasible to continue beyond DELDA and return to ISB in the event of an engine failure, whereas this may not be achievable at a lower FL. Therefore, it is strongly recommended to always account for the second dimension (vertical axis), i.e., your FL, when considering DELDA as the CP.

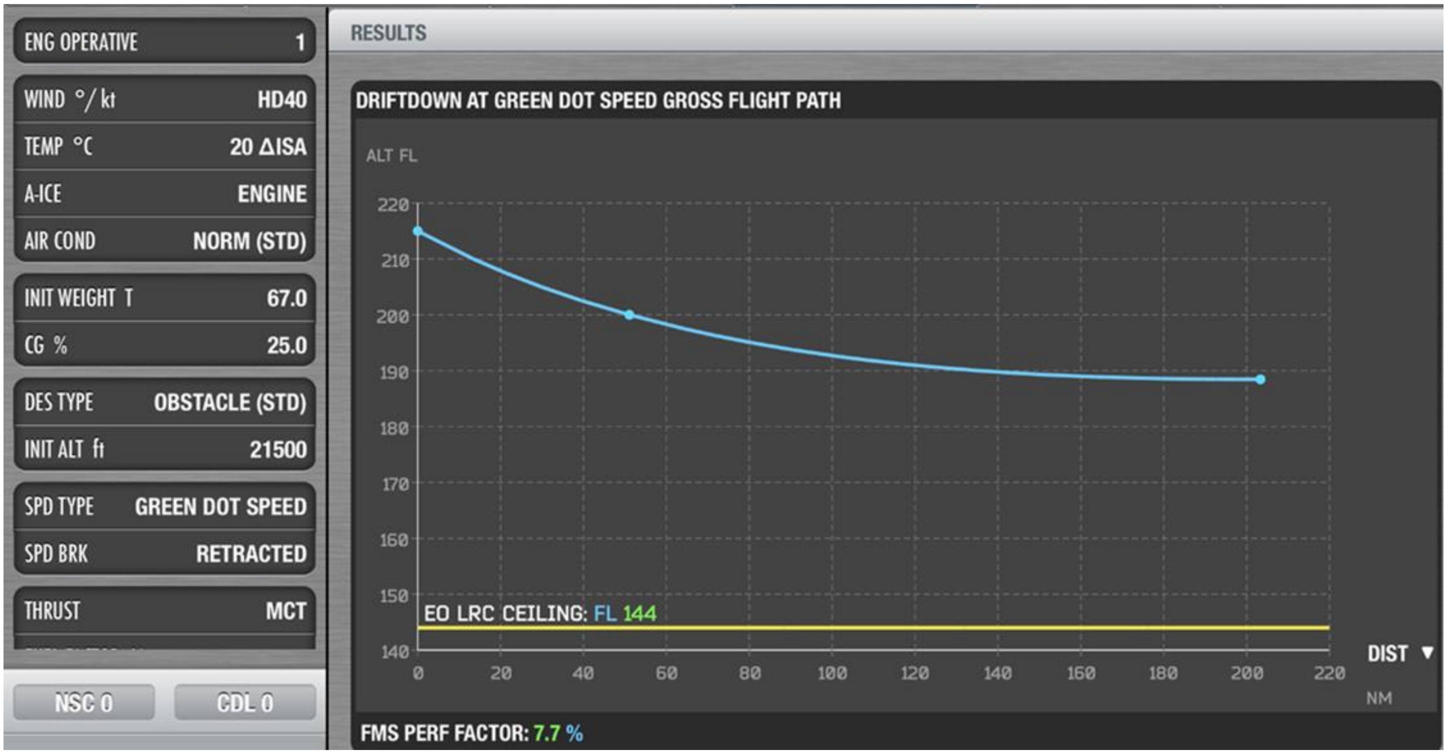
A 135° turn after DELDA at a higher flight level may provide a similar level of safety as a 180° turn before DELDA (refer to the driftdown profiles in the images below). Failing to calculate or evaluate driftdown performance before reaching DELDA could result in continuing into high terrain with a single engine — a situation that is often easily avoidable. If performance allows for a safe return, there is no justification for accepting the risks associated with driftdown into terrain simply because DELDA has been crossed. Therefore, it is crucial to assess driftdown performance early in the cruise phase to plan contingencies effectively, rather than relying on a fixed point as the CP every time. The primary objective is to prevent entering the Skardu valley with one engine inoperative.

Flying to KDU might be faster but poses greater risks compared to diverting to ISB. The single-engine 1-hour cruise range in still air and ISA conditions is 350 NM, while the total distance from KDU to ISB is much less than 350 NM, which ensures that landing after an engine failure remains within regulatory limits from any point along the route. There is no strict regulation mandating a landing at the nearest airport following an engine failure. Proximity alone does not guarantee safety. The safest option must be chosen based on considerations such as weather, airport conditions, safety factors, and the operational status of the aircraft.

The above performance applies to aircraft with a performance factor of 2.7%. As shown, the aircraft can comfortably maintain FL215 even with significant ISA deviation, high weight, and a forward CG. Performance is calculated at 67 tons because weight near DELDA is unlikely to exceed this value. With a maximum landing weight limit of 66 tons and DELDA being close to the aerodrome, exceeding 67 tons at DELDA would prevent sufficient fuel burn before touchdown, resulting in a landing weight violation. Therefore, the flight plan is designed to avoid such scenarios. However, aircraft with different performance factors may not achieve the same capabilities. Let’s review other profiles to understand this better. The image below is for an aircraft with a performance factor of 7.7%. At the same weight of 67 tons, with a forward CG and ISA+25, its ceiling would be around 175, notably lower than the case above.

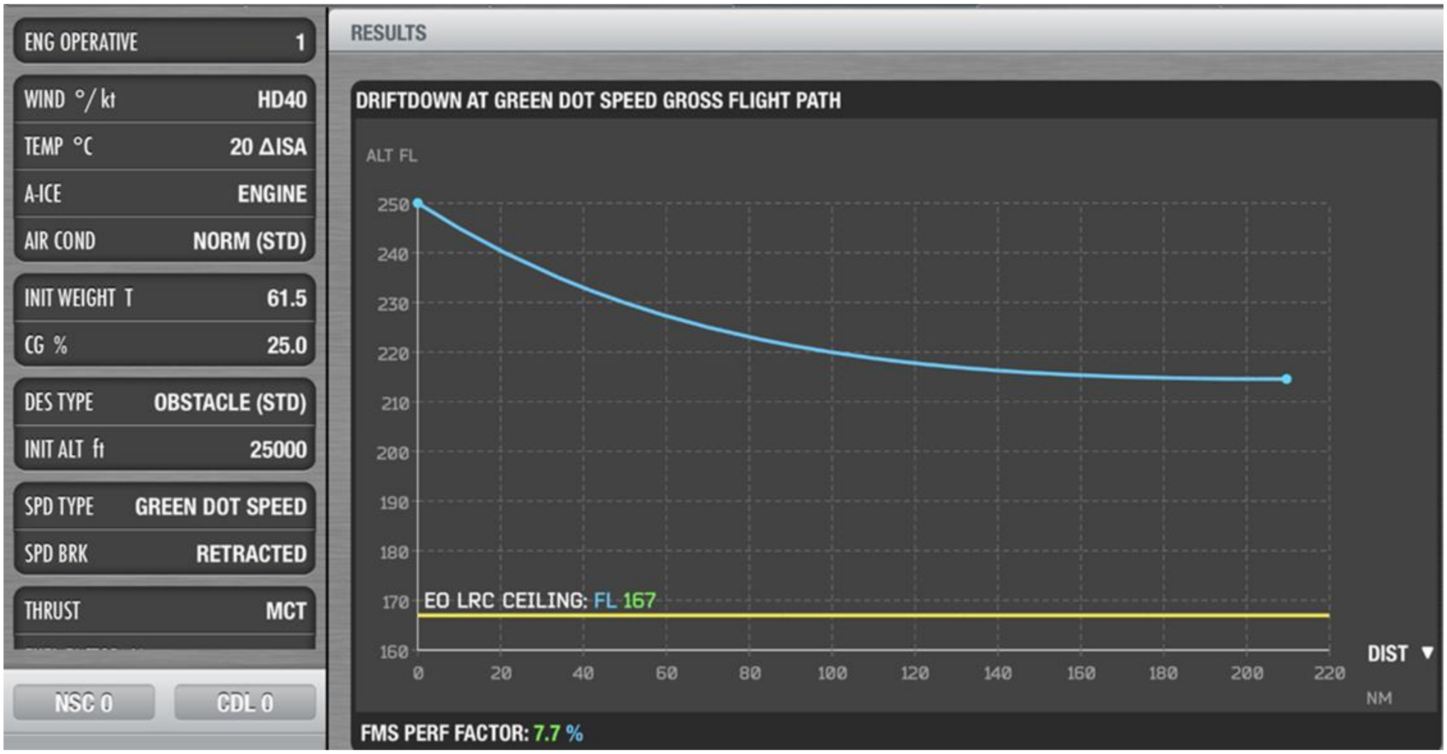


However for the same performance factor of 7.7%, with better ISA conditions, FL190 would become the ceiling.



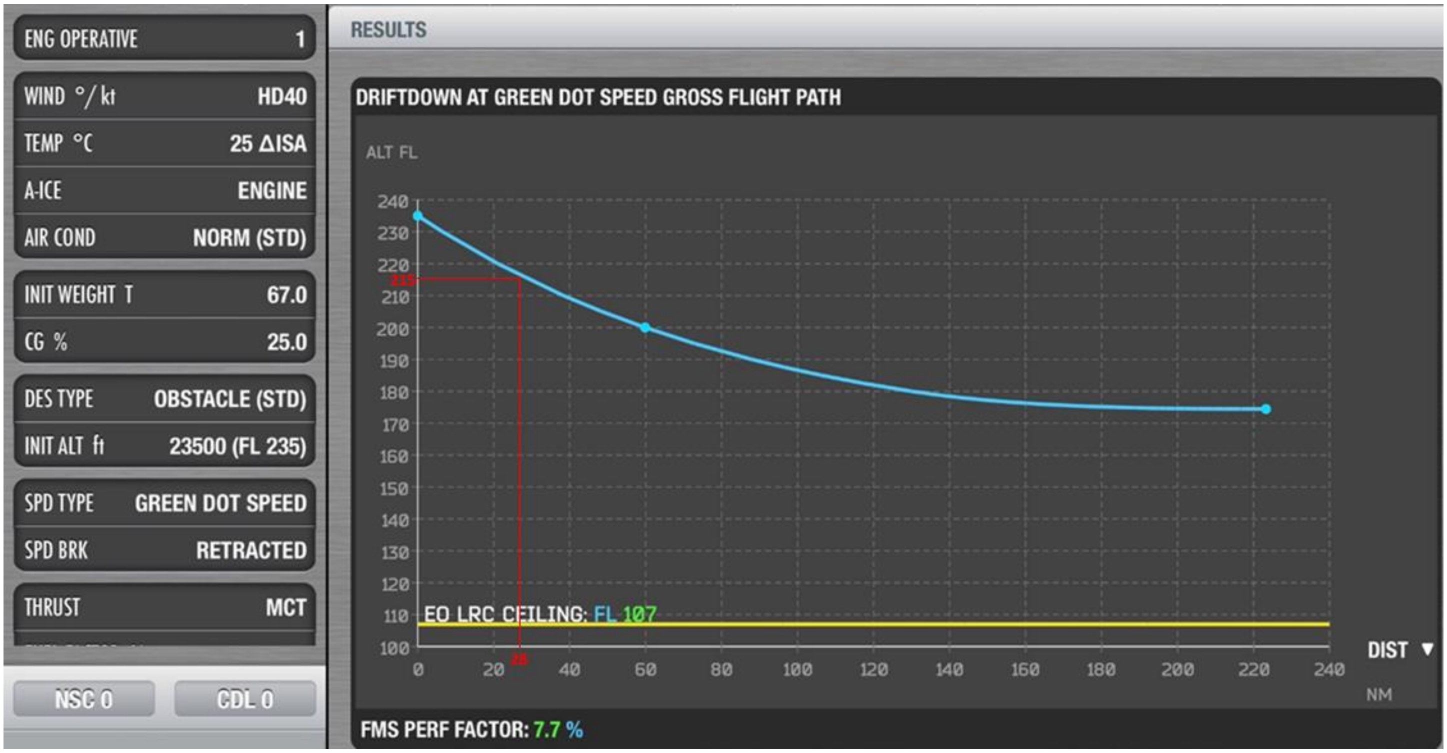
With improved ISA conditions & reduced weight, FL215 would become the ceiling, effectively resolving all issues.

With additional altitude, better ISA & reduced weight, even low-performance aircraft can operate effectively.

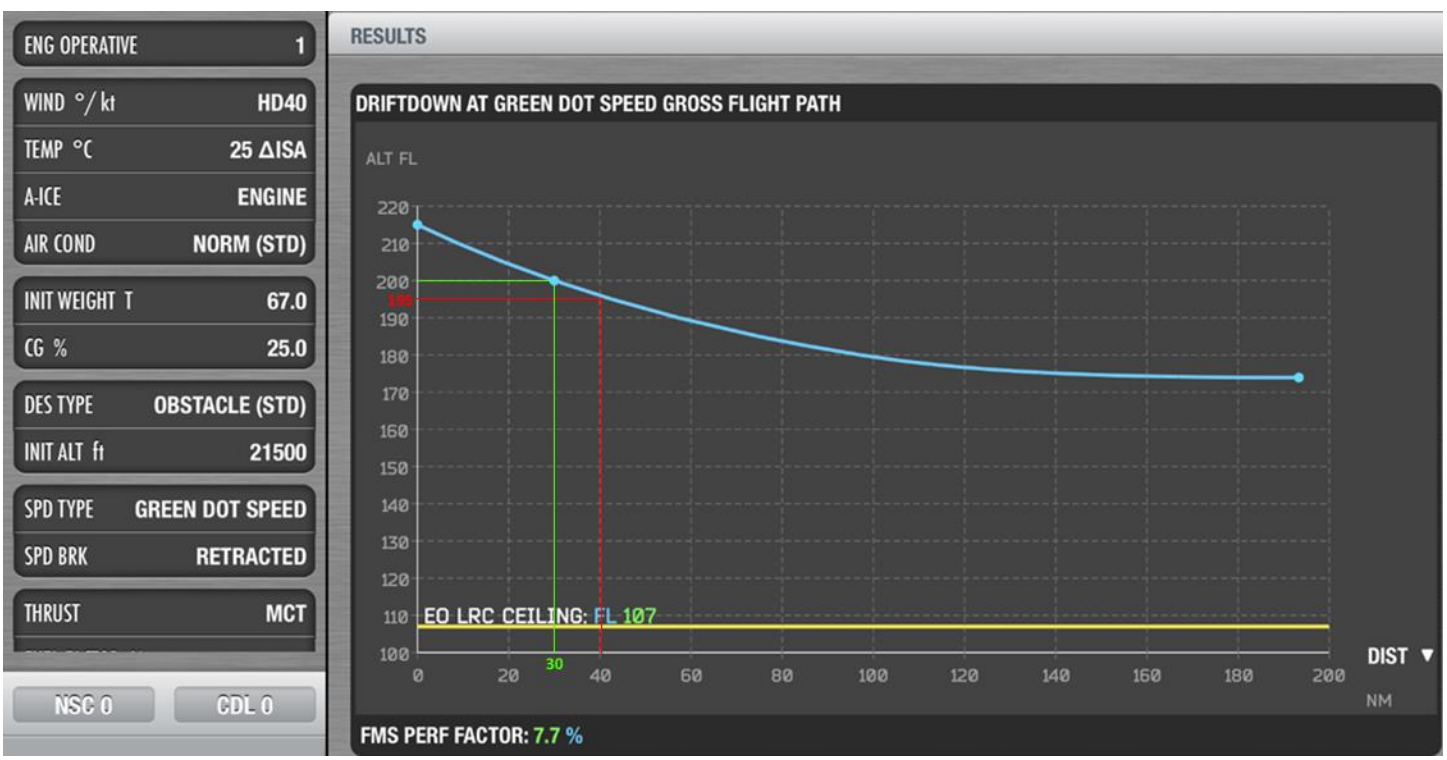


Whereas with less favorable ISA conditions and higher weight, if you have additional altitude, you can clear the terrain with legal margins since extra altitude provides an added safety buffer. Therefore your altitude and single-engine ceiling are key factors in determining your course of action. As shown below, the distance from DELDA to DOFANA is about 11.8 NM, and from BIREB to DOFANA, it's 21.8 NM. The shortest distance between DOFANA and the line joining DELDA and BIREB is 8.8 NM. This means that distance between DOFANA and any point located on the line between DELDA and BIREB will be within 8.8 to 21.8 NM.

Based on the performance figures shown below, starting a driftdown at FL235 from any point on the DELDA-BIREB line will clear Dofana with a 2000 feet margin, as FL215 (Dofana + 2000) will be reached 6.2nm (28-21.8) or more after crossing Dofana. Some distance is lost in the turn, but this can be easily managed e.g., a 180° turn over the Indus Valley to DELDA and then BUNGI on a day with reduced performance.



If drift down starts from FL215 (no extra height) with poor performance (as shown below), FL195 (Dofana height) will be reached 19.2nm (41-21.8) or more after Dofana – Clearing it but without 2000ft margin. You can visually avoid (180° turn over Indus) or maneuver around it since surrounding peaks are at or below 18000ft & 2000ft clearance requires to cross them at FL200 which will be reached 8.2nm (30-21.8) or more after crossing them.



After reviewing all available options, it is important to remember that diversion is not mandatory if weather and conditions allow a safe landing in Skardu. The key is to understand your options and limitations, staying calm to prevent unnecessary risks and challenges during an emergency. One must carefully assess the situation to ensure they do not create a demanding or hazardous scenario while trying to land quickly.

SINGLE ENGINE GO-AROUND

There are two main things to consider for a single engine go-around:

- Aircraft Configuration
- Go-around Trajectory

Aircraft Configuration: It is recommended to use Flaps 3 for landing since the runway length is sufficient, and there are no performance concerns. The key advantage of a Flaps 3 landing is that in the event of a single-engine go-around, selecting flaps one notch up will result in climbing out with Flaps 2, which provides better performance during maneuvers compared to climbing out with Flaps 3 (as would be the case with a full-flaps landing). This scenario was tested in the simulator, where it was observed that during a single-engine go-around, maneuvering with Flaps 3 in tight turns led to a speed drop into VLS, particularly when the aircraft was heavy and air density was low.

Go-around Trajectory: As far as trajectory is concerned, see the image below:

Initially, maintain runway heading, then turn left to track between the Kidney Hills and the terrain on the right. Unlike a two-engine go-around, where climb thrust is selected at 1,000 feet and the aircraft continues to climb, a single-engine go-around requires leveling off to complete the clean-up process and setting MCT as per procedures. Additionally, the climb performance will be significantly lower than in a two-engine go-around. The typical 1,500-foot level-off will be approximately at the height of the first Kidney Hill, while the 2,000-foot level-off will be near the second Kidney Hill. As a result, rather than flying over the hills, you will likely be maneuvering between them due to the clean-up and thrust setting procedures combined with limited climb performance.

As mentioned earlier in the document, the recommended speed for maneuvering, especially for 180° turns in the valley, is 160-170 knots to maintain control over the turning radius. Since you are only accelerating to 160-170 knots rather than Green Dot speed, the reduced acceleration requirement allows for an earlier transition to the climb phase. If landing with Flaps 3, you will already be in a Flaps 2 configuration (one notch up), which is typically suited for flying at 160-170 knots. Therefore, after completing the initial actions, your primary focus should be on maintaining your climb and executing the turns efficiently.

To begin the turn towards the runway, it may be tempting to turn in a way that keeps the aircraft between the runway and the first kidney hill, as there is no terrain in this area. However, due to single-engine performance and maneuvering limitations—such as the 15° bank restriction and higher TAS—this may not always be feasible (a detailed discussion on this follows next under "Single Engine Takeoff Performance"). A more practical option is to turn between the first and second kidney hills. Climbing to 9,500 feet before initiating the turn into the space between the hills is ideal, as it ensures safe clearance over the second hill even if the turn radius increases. If climb performance does not allow this—especially in high temperatures and heavy-weight conditions—make sure to start the turn before crossing abeam Satpara Lake to ensure an easy path between the hills (see the “Engine Failure at Takeoff” section for more details). This minimizes the need for an increased bank angle and reduces the risk of getting too close to the second hill.

If, for some reason, you are unable to turn between the first and second kidney hills, then turn between the second and third kidney hill. This turn is tighter compared to the one between the first and second hills. Given the single-engine performance limitations, it is unlikely you will be able to fly over the third hill, so ensure you stay well clear of it during the turn. Plan the turn to avoid excessive bank angle. However, if performance allows (TOGA thrust, light weight and cooler temperatures), climb to 10,500 feet before initiating the turn between the hills to safely clear the third kidney hill in the event of an increase in the turn radius.

The target missed approach altitude should be at least 10,300 feet, if not 11,500 feet. The former will keep you clear of the first & second hill, while the latter ensures clearance from all three hills. Once you have successfully turned towards Skardu, orbit between the runway and the first hill to have maximum terrain clearance.

DEPARTURE FROM SKARDU

PREFLIGHT

- MTOW: 65 tons or less due PCN limitation for runway 14L. No weight restriction for runway 14R.
- FMC: Thrust Reduction/Acceleration = 8300/10300.
- FMC: Speed Green Dot till FL215.
- Take off Performance: Analyze one engine climb performance, trajectory and maneuvering capability.

NORMAL TAKEOFF

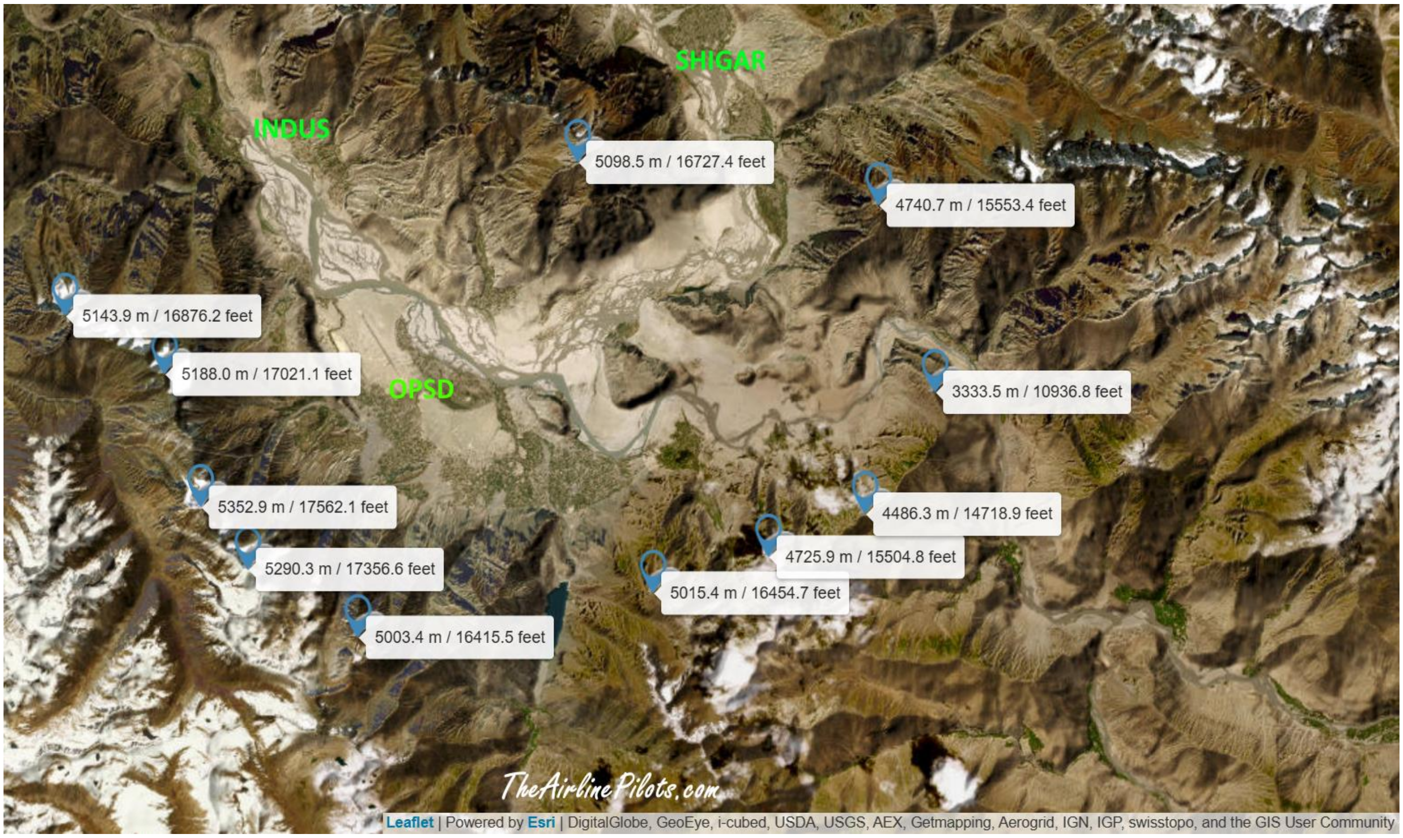
- Standard CONF 2 takeoff is recommended.
- Maintain runway heading.
- At 1000 feet AGL – Reduce thrust.
- Abeam kidney hills turn left on an easterly heading.

- Continue climbing with takeoff speed and flaps set to 2 to gain altitude. Keep the speed restricted to 160-170 knots for maneuvering in the valley. Accelerate at a height that ensures you have adequate terrain clearance from the Kidney Hills. In hot weather and at heavier weights, the typical acceleration height of 10,300 feet may not be reached quickly. Depending on your maneuvers and position in the valley, you might find yourself in a situation where this acceleration height does not provide enough clearance, such as when you are close to the third Kidney Hill, which has a peak of 10,400 feet. Therefore, before accelerating to clean up, plan your maneuvers and course setting strategy, and accelerate at a height that gives you sufficient clearance from all the kidney hills.

- Accelerate to Green Dot speed and continue climbing at this speed until approximately 21,500 feet. The benefits of reaching this altitude have already been discussed in detail earlier in this document.

- Depending on your strategy and weather, set course via Skardu or Shigar valley.

- While climbing out, ensure that sufficient aircraft performance is available to clear the terrain, keeping in mind that an engine-inoperative condition, if encountered, can significantly decrease climb performance. If poor climb performance is anticipated or observed, it is recommended to maneuver in the valley, gain sufficient altitude, and then set your course. Refer to the height of the hilltops around the airfield in the image below for further guidance.



- Set standard altimeter setting after crossing transition altitude.

- At FL215, accelerate to the max rate of climb or your desired speed.

ENGINE FAILURE AT TAKEOFF – PERFORMANCE

Single-engine takeoff performance analysis is critical before departing Skardu. Failing to assess it properly can lead to unexpected and potentially dangerous situations. However, having a clear mental picture of single-engine performance ensures a safer and more controlled flight.

The three key aspects to evaluate are:

1. Climb Performance – Assessing 2nd segment climb to MAX EO ACC ALT.
2. Climb Trajectory – Time and distance to reach MAX EO ACC ALT.
3. Maneuvering Capability – Evaluating the radius for 180^{o} turns.

CLIMB PERFORMANCE – ASSESSING 2^{ND} SEGMENT CLIMB TO MAX EO ACC ALT

Wind 320/5 – T20°C (**ISA+19**) – **Q1020** – CG > 27% – Flaps 2 – Airconditioning ON – Anti-Ice OFF – RW 14R Dry													
W	Aircraft Performance Factor – **2.7%**						W	Aircraft Performance Factor – **7.7%**					
	FLEX			**TOGA**				**FLEX**			**TOGA**		
	V2	2^{ND} SEG	MAX EO ACC ALT	V2	2^{ND} SEG	MAX EO ACC ALT		V2	2^{ND} SEG	MAX EO ACC ALT	V2	2^{ND} SEG	MAX EO ACC ALT
74	144	2.68	9320	144	2.86	9523	74	-	-	-	-	-	-
70	141	2.56	9232	140	3.51	10202	67	-	-	-	149	2.45	9429
65	145	2.73	9599	135	4.42	11150	65	148	2.43	9431	147	2.79	9848
60	141	2.80	9757	129	5.50	12160	60	143	2.48	9472	141	3.73	10941
Wind 320/5 – T30°C (**ISA+29**) – **Q1015** – CG > 27% – Flaps 2 – Airconditioning ON – Anti-Ice OFF – RW 14R Dry													
W	Aircraft Performance Factor – **2.7%**						W	Aircraft Performance Factor – **7.7%**					
	FLEX			**TOGA**				**FLEX**			**TOGA**		
	V2	2^{ND} SEG	MAX EO ACC ALT	V2	2^{ND} SEG	MAX EO ACC ALT		V2	2^{ND} SEG	MAX EO ACC ALT	V2	2^{ND} SEG	MAX EO ACC ALT
70	140	2.53	9123	141	2.65	9238	66	147	2.48	9404	147	2.51	9434
65	145	2.78	9561	135	3.50	10106	65	147	2.47	9398	146	2.68	9640
60	141	2.73	9585	130	4.49	11067	60	143	2.53	9453	140	3.61	10703

W = Weight in tons | V2 in KIAS | 2^{nd} Segment Climb Gradient in % | Max engine out Acceleration Altitude in feet.

The table above presents takeoff speed, climb gradient, and max engine-out acceleration altitude for aircraft with different performance factors, derived from the NAVBLUE performance app. The green section presents performance data for aircraft with a 2.7% performance factor in ISA +19 with a 5-knot tailwind, while the grey section shows data for aircraft with a 7.7% performance factor under the same conditions. Similarly, the yellow section reflects performance data for aircraft with a 2.7% performance factor in ISA +29 with a 5-knot tailwind, whereas the red section shows performance data for aircraft with a 7.7% performance factor under the same conditions. The data is based on summer conditions, where performance limitations are most critical, and includes multiple takeoff weights with both Flex and TOGA thrust. While these factors vary with each takeoff, the key objective is to assess general single-engine performance, particularly in relation to the surrounding terrain.

First point to note is that, regardless of weather or aircraft performance factor, <u>the maximum engine-out acceleration height with a flex takeoff will remain relatively low</u>, close to the height of the second kidney hill. In contrast, a TOGA takeoff provides a higher acceleration altitude. Unless temperatures are very low and the aircraft is exceptionally light, a flex takeoff typically results in a maximum engine-out acceleration altitude near 9,300 feet (height of 2^{nd} hill). Therefore, it is crucial to **select TOGA in the event of an engine failure during a FLEX takeoff**.

If the weather is hot and the aircraft is heavy (yellow area), even a TOGA takeoff may not ensure sufficient clearance over the second kidney hill, especially with a poor performance factor (red area). However, in milder temperatures and at lower weights (green & grey areas), TOGA can provide a higher engine-out acceleration altitude, allowing safe clearance over the second hill.

When operating near maximum weight limits, even in moderate temperatures, TOGA may not always provide enough clearance over the second hill. Aircraft with better performance factors (green area) may still face limitations, while those with poorer performance factors (red and grey areas) will only benefit from TOGA at lighter weights and in cooler conditions.

The second key point to note is that with a flex takeoff, the climb gradient remains barely above the legal limit of 2.4%, regardless of weather or aircraft performance factor, whereas TOGA thrust significantly improves it. The 2^{nd} segment climb gradient directly impacts both time and distance to reach the acceleration altitude.

- Lower Gradient → Longer Time & Distance to Acceleration Altitude → Reduced Terrain Clearance.
- Higher Gradient → Shorter Time & Distance to Acceleration Altitude → Better Terrain Clearance.

Therefore, as mentioned earlier, **select TOGA in the event of an engine failure during a FLEX takeoff.**

CLIMB TRAJECTORY – TIME AND DISTANCE TO REACH MAX EO ACC ALT

From the data in the table above, we can compute time and distance values to the maximum engine-out acceleration altitude and overlay them on the map to assess our position in case of an engine failure during takeoff.

Let us consider a flex thrust takeoff at 65 tons in ISA+19 conditions with an aircraft that has a poor performance factor. In this case, V2 is 148 KIAS, the 2nd segment climb gradient is 2.43%, and the max engine-out acceleration altitude is 9,431 feet.

The first step is to convert IAS to TAS. As a rule of thumb for lower altitudes, TAS increases by approximately 2% per 1,000 feet of altitude. For an airfield elevation of 7,300 feet:

7300 / 1000 = 7.3 (per thousand feet)

7.3 x 2% = 0.146 (TAS increase factor)

0.146 x 148 (V2) = 21.6 (speed increment)

TAS = 148 + 21.6 = 169.6 knots.

Similarly, TAS for 8,300 and 9,300 feet will be 172 and 175 knots, respectively. For precise results, an E6B flight computer can be used, factoring in temperature and pressure. To climb from 7,300-foot runway elevation to 9,300-foot height of the second kidney hill, we will use an average TAS of 172 knots.

Rate of Climb (ROC) = TAS (172) x Gradient (2.43) = 418

ROC = 418 x 1.013 (knots to fpm conversion) = 423 fpm

Although the MAX EO ACC ALT is 9,431 feet, we will consider climb up till 9,300 feet.

Altitude to climb is 9300 – 7300 = 2000 feet.

Time to Climb = 2000 feet / 423 fpm = 4.73 mins.

Since we considered a 5 knots tailwind, our GS will be TAS 172 + 5 = 177 knots.

A GS of 177 is 2.95 nm per minute (177/60).

If the climb lasts 4.73 minutes, the distance covered will be 4.73 × 2.95 = 13.95 nm (approximately 14 nm).

If you run the same calculations for an aircraft with a better performance factor while keeping all other factors constant (65-ton weight, ISA+19 weather, and flex thrust), the distance for a 2,000-foot climb is 12.41 nm (in 4.28 minutes) with a V2 of 145 knots and a climb gradient of 2.73%. This is better than an aircraft with poor performance but still not significant. However, with TOGA thrust under the same conditions, the distance for a 2,000-foot climb reduces significantly to 7.68 nm (in 2.84 minutes) with a V2 of 135 knots and a climb gradient of 4.42%. Additionally, with TOGA, the max engine-out acceleration altitude increases to 11,150 feet, allowing for a 3,000-foot climb—1,000 feet above the second hill—with a total climb distance of 11.52 nm (in 4.26 minutes).

Now, refer to the image below to see where these distances fall on the map and determine your lateral and vertical position at the time of acceleration and MCT setting under various takeoff scenarios.

This highlights the importance of thorough preflight takeoff analysis, as these factors vary with each departure and must be assessed to visualize single-engine performance and its impact on your departure. **Note:** The rate of climb (ROC) calculated above — and consequently the estimated time & distance to reach acceleration altitude — assumes a straight, unbanked climb. However, as observed in the simulator, during 15° banked turns, the ROC can decrease significantly, in some cases dropping to as low as 100 fpm or less. Given the topography in this area, it will not be possible to maintain straight flight for long; turns will be inevitable. Therefore, in actual conditions, your average ROC will likely be much lower than the calculated straight-climb value.

MANEUVERING CAPABILITY – EVALUATING THE RADIUS FOR 180^{O} TURNS

The main purpose of this calculation is to determine whether a 180° turn can be completed before reaching the first kidney hill. The formula used is:

$R = V^2 / g \times \tan(\theta)$
Where:
R = Turn radius (meters or feet)
V = True airspeed (m/s or ft/s)
g = Acceleration due to gravity (9.81 m/s² or 32.2 ft/s²)
θ = Bank angle (degrees)

Let us compute some values under the same conditions discussed earlier, starting with an aircraft that has a poor performance factor and is using a flex thrust takeoff.

TAS = 171 KIAS (average of TAS at 7,300 and 8,300 feet)

TAS = 171 x 6076 / 3600 = 289 feet per second

R = 289^2 / 32.2 x tan (15) = 9,664 feet

R = 9664 / 6076 = 1.59 nm

Turn distance for a 180^o turn = R 159 x 2 = 3.18 nm

Similarly, for an aircraft with a better performance factor using a flex thrust takeoff, the total turn distance for a 180^o turn is approximately 3.05 nm. However, with TOGA thrust—where V2 is lower—the turn distance reduces to 2.65 nm. This does not yet account for wind effects, which can further increase the turn radius. If the aircraft turns 20^o right immediately after takeoff to create room for the turn, the maximum available distance is around 3.2 nm. However, if runway heading is maintained for longer before initiating the turn, the available distance will be even less (around 2.4 nm).

In most cases, the distance is insufficient for completing a 180° turn before the first kidney hill. However, under better environmental conditions, with a lower takeoff weight, TOGA thrust, and a reduced V2 (e.g., 130 knots), the turn distance could be as low as 2.5 nm in no-wind conditions—potentially allowing the turn before the first hill, though with minimal margin.

So, do not force a turn before the first hill by increasing the bank angle, as this will cause your speed to drop into VLS. If you can complete the turn comfortably, go for it; otherwise, continue between the first and second hills. Turn assessment before takeoff helps visualize performance limitations specific to the day's conditions.

To simplify calculations, you can use our **Climb & Turn Performance** app to determine the turning radius and distance to the max engine-out acceleration altitude by entering your takeoff performance data and assessing single-engine performance accordingly.

ENGINE FAILURE AT TAKEOFF – PROCEDURE

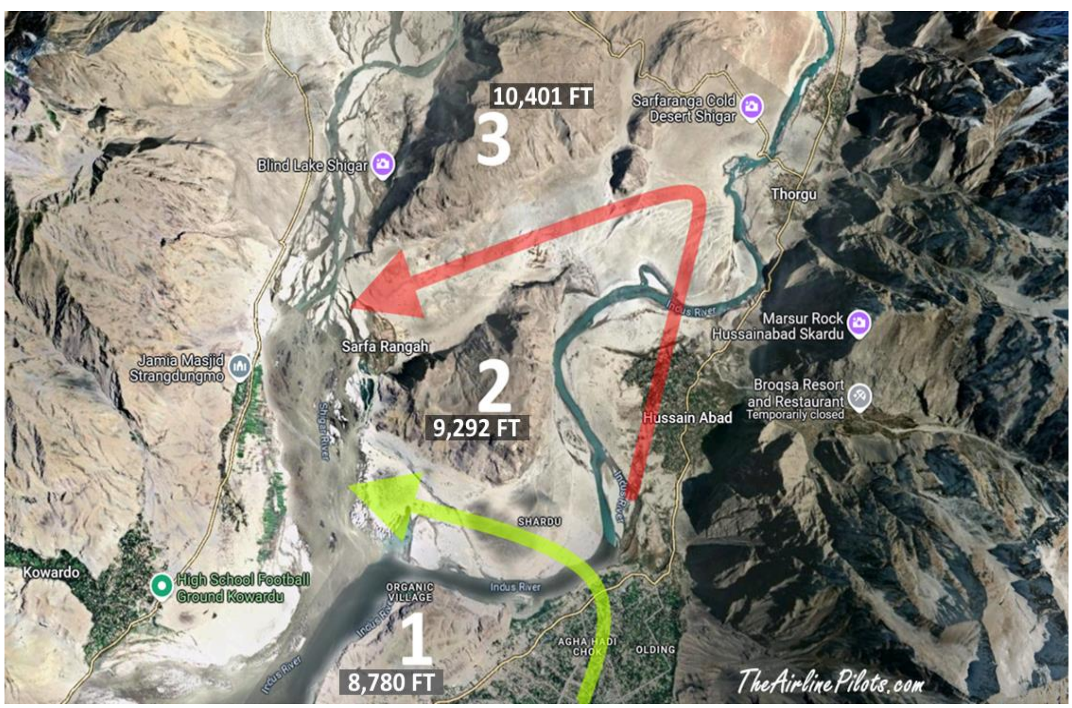
Based on the single-engine performance discussed above, three key factors to focus on during an engine failure at takeoff, aside from the routine one-engine-out procedures, are:

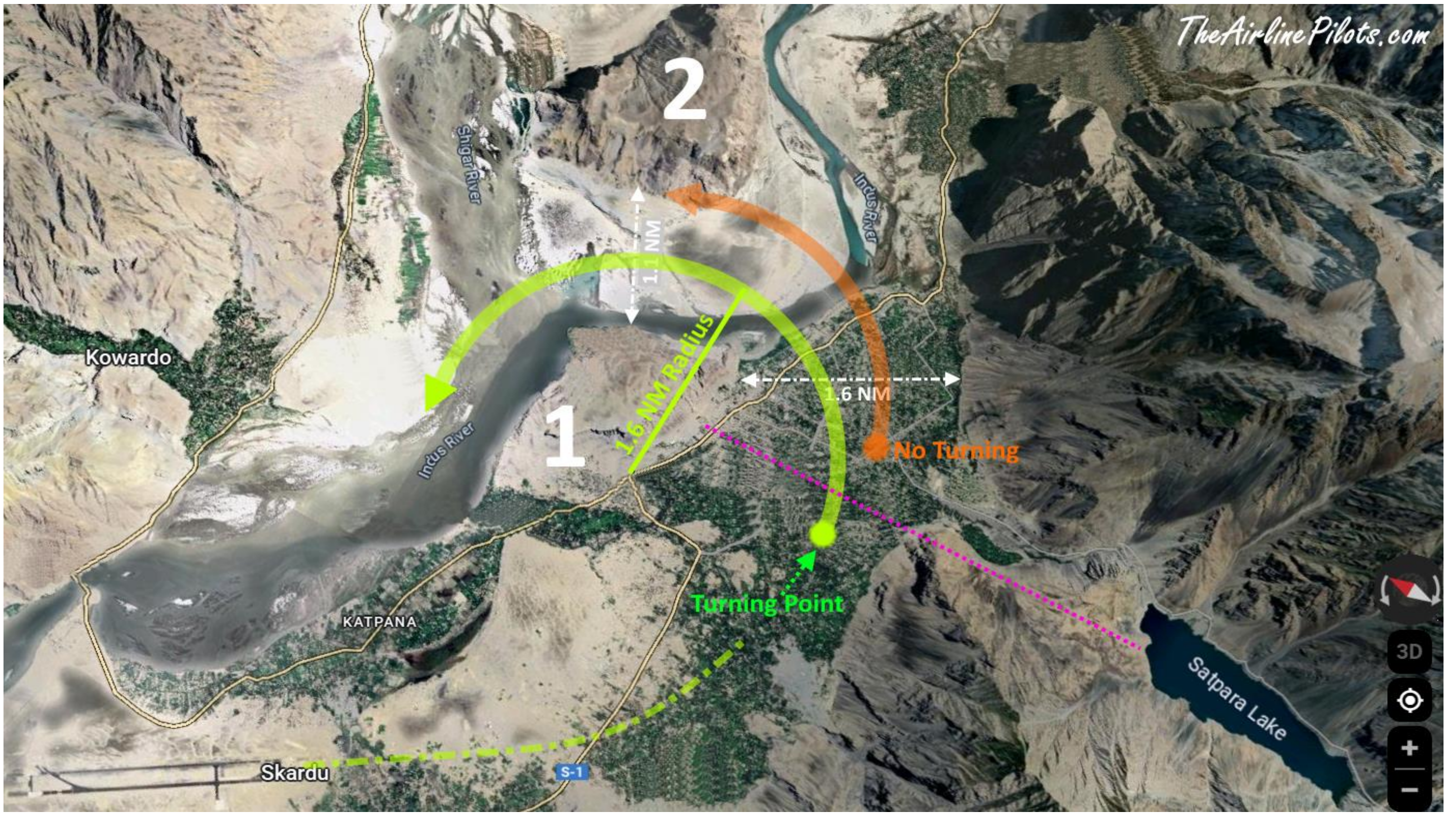
- **Selecting TOGA thrust** when departing with FLEX thrust.
- **Maneuvering** to avoid the Kidney Hills.
- **Speed Control** to manage turning radius effectively.

Once your thrust is set, concentrate on your maneuvers while maintaining control of your bank angle and speed. Ideally, the best area to remain within is between the runway and the first kidney hill, as this keeps you clear of any terrain below. However, achieving this may only be feasible under extremely low weight and temperature conditions. In most takeoff scenarios, performance and maneuver limitations—especially the 15° bank restriction and higher true airspeed (TAS) in this area—may make it impractical, particularly in a single-engine condition, as discussed earlier.

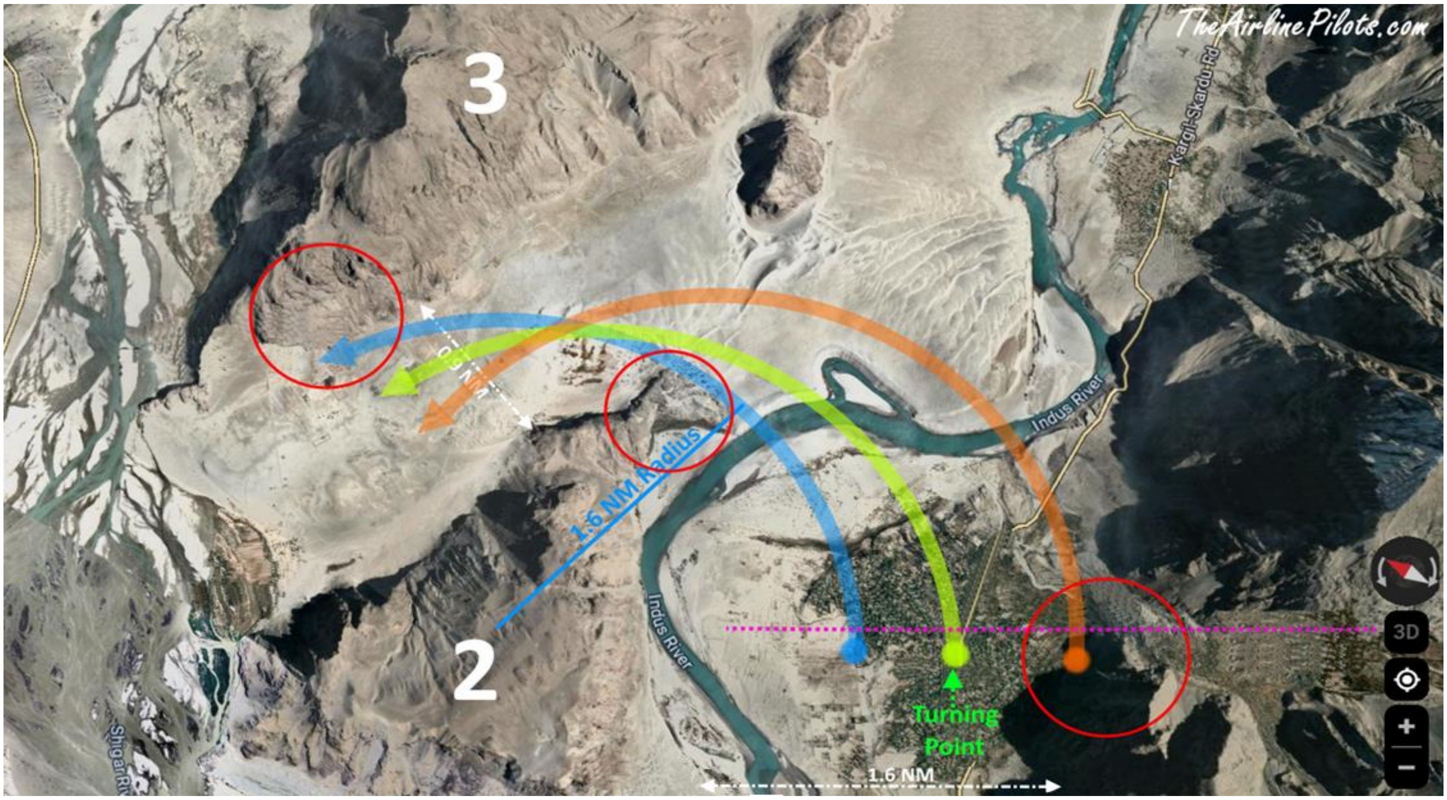
If performance allows and you anticipate being able to turn before the first kidney hill, initiate a slight right turn of approximately 20 degrees immediately after becoming airborne. Maintain this heading for about 1 to 1.5 NM to create space for your left turn. After starting the left turn, ensure you do not exceed safe bank angles to complete the turn before the first hill. If turning before the first hill is not feasible, discontinue the turn in a timely manner and continue on an easterly heading to plan your turn between the first and second hills instead.

If you choose to maintain the runway heading after takeoff, turn left onto an easterly heading once abeam the kidney hills. In this case, your strategy should be to maneuver between the first and second kidney hills to maximize terrain clearance while gaining altitude to orbit over the airfield. Avoid extending beyond the second hill, as single-engine climb performance—especially in hot weather and with a heavy aircraft—may bring you dangerously close to the terrain. Turning between the second and third kidney hill requires more than 90 degrees of heading change, which will degrade climb performance. Additionally, the combination of topography and turn angle may bring you uncomfortably close to the third Kidney Hill, the highest in the area at 10,401 feet. This proximity, or even the perception of it, may incline you to increase your bank angle to complete the turn, which is not desirable as it can further reduce climb efficiency and increase the risk of altitude loss.





The image above illustrates turning arcs based on a previously calculated turn radius of 1.6 NM with a 15° bank. After takeoff and initiating a left turn, the optimal flight path typically follows the center of the valley. As shown by the green arc, starting the turn at the correct point allows for a smooth transition between the first and second hills. However, if the turn is initiated too late, a 15° bank will not be sufficient to navigate between these hills. As a rule of thumb, be prepared to turn before reaching abeam Satpara lake valley, indicated by the pink dotted line in the image. The image below shows turn challenges between the 2nd and 3rd hill.



The turning point in this scenario is abeam “Husain-Abad Waterfall” or before reaching abeam the valley on your right (indicated by the pink dotted line). However, if you initiate the turn from your typical position in the center of the valley (blue dot), you encounter two critical points during the turn, marked by red circles on the blue arc — one near the 2nd hill and the other near the 3rd hill. These points are critical because the aircraft gets close to the terrain during the turn, increasing the risk of insufficient clearance. To avoid this, if you drift north to position yourself for turn initiation so that you can fly in the center of these hills, it creates another critical point — which is proximity to the hill on your right, as shown by the red circle on the orange dot. The optimal turning point lies between these two positions, marked by the green dot, but finding this balance may not be easy. A slight miscalculation can either bring you close to the surrounding hills or leave you without enough room to complete the turn safely.

Performance and influencing factors, such as aircraft weight, wind conditions and density altitude, will vary with each departure. It is essential to plan thoroughly and visualize the maneuver accordingly to ensure a safe and efficient climb-out. Once the engine out acceleration height is achieved:

- Push to Level OFF.
- Maintain takeoff flaps, accelerate to, and fly the F speed, which should be close to 160-170 knots.
- Set MCT.
- Continue climbing to a safe height.

Complete the required procedures and then join left downwind to land at Runway 14. Extending the gears can be delayed in case of high temperatures and weight.

Disclaimer: "A320 SKARDU OPERATION" is a personal research work by the undersigned, aimed at developing flight procedures for airfields surrounded by high terrain. This document does not authorize any pilot to deviate from their Company's Standard Operating Procedures, Aircraft Manuals or Manufacturer's Recommendations. Terrain maps and elevation data are sourced from Google and FreeMapTools.com while TheAirlinePilots.com owns the photo images and graphics.