Cruise limitations in mountainous area assessment
Airbus A320-200 with V2527-A5 engines

In this project you will assess the cruise limitations for an Airbus A320-200 aircraft scheduled to fly from Dubai International Airport (OMDB), United Arabian Emirates, to Beijing Capital International Airport (ZBAA), China. The main goal of the project is to study the impact of a sudden loss of cabin pressure or an engine failure at the critical point(s) of the route. The outcome of this study will be an operational chart depicting the portion of the route studied along with all critical or relevant fixes, diversion routes (if any), alternative airports and specific procedures to follow by the aircraft crew in case of one of these emergencies.

The portion of interest of the route, as filled in the ATS flight plan[1], is shown below:

MAXMO – A419 – BND – A453 – KN – A453 – GN – A453 – KB – G206 – PURPA –W112 – HTN – W112 – QIM – W112 – NOLEP – W112 –CHW – B215 – YBL – A596 – DKO – A596 – BAV– A596 – SZ – A596 – TZH – A596 – KM

The aircraft is dispatched with a take-off mass of **69 000 kg**, a cruise altitude of **FL370** until PURPA fix and **FL371** upon it (in order to comply with the metric Chinese cruising flight levels).

In terms of the route study, several considerations must be taken into account:

1. The portion of the route to be studied is limited from Ghazni NDB (GZ) to NOLEP fix. The route before GZ and after NOLEP is out of the scope of this study. Consider these two points as non-return points (NRP) in case a loss of cabin pressure or an engine failure.
2. For the considered segment of the route, the en-route alternative airports available and suitable **are only**: Peshawar Intl., Pakistan (OPPS); Benazir Bhutto Intl., Islamabad, Pakistan (OPRN); Kashi/Kashgar, China (ZWSH); Hotan, China (ZWTN).
3. In case of an emergency at any point of the route (depressurization or engine failure) **at least two enroute alternative airports must be reached**.
4. For the portion of the route studied, assume that the mass of the aircraft is approximately 60 000 kg at the moment the emergency occurs.
5. Consider ISA-10^{o}C atmospheric conditions along the entire route (affecting, basically, the true altitude and the engine performance).
6. Assume no-wind conditions all along the flight.
7. Consider EU-OPS regulations and that the aircraft is RNP equipped (i.e. a $\pm$5NM corridor width can be used along the route for the obstacle assessment study).
8. Despite your RNP equipment, all route diversions **must follow VOR radials or NDB courses**.
9. In case a turn with more than 90^{o} of course change is done, a time penalty of 2.5 minutes must be applied. For turns of less than 90^{o}, no time penalty is considered.
10. The aircraft is equipped with a 22 minutes chemical O_2 system. In case of loss of cabin pressure this system limits the altitude of the aircraft in such a way that it must **remain always below** the vertical profile shown in Figure 1.
11. In case of loss of cabin pressure the aircraft will execute descends at the maximum operative airspeed (MMO/VMO) with speedbrakes extended and level flights at maximum speed with maximum cruise

[1] To obtain the coordinates of all fixes use the website: *http://skyvector.com*

thrust (MCT). The emergency descent will be conducted up to FL100, where long range cruise (LRC) speed will be retained.

12. In case of engine failure the aircraft will descend following a drift-down procedure according to the given diagram provided in annex to this document ("Fish-bone" diagram).
13. Whenever possible try to minimize the number of course changes, diversion routes and altitude variations.
14. Remember to consider Chinese metric flight level system for any route ahead of PURPA fix (see Figure 2).
15. The terrain obstacle assessment must be done with an image editor software. Some open-source recommendations are *inkscape*[2] or *gimp*[3].

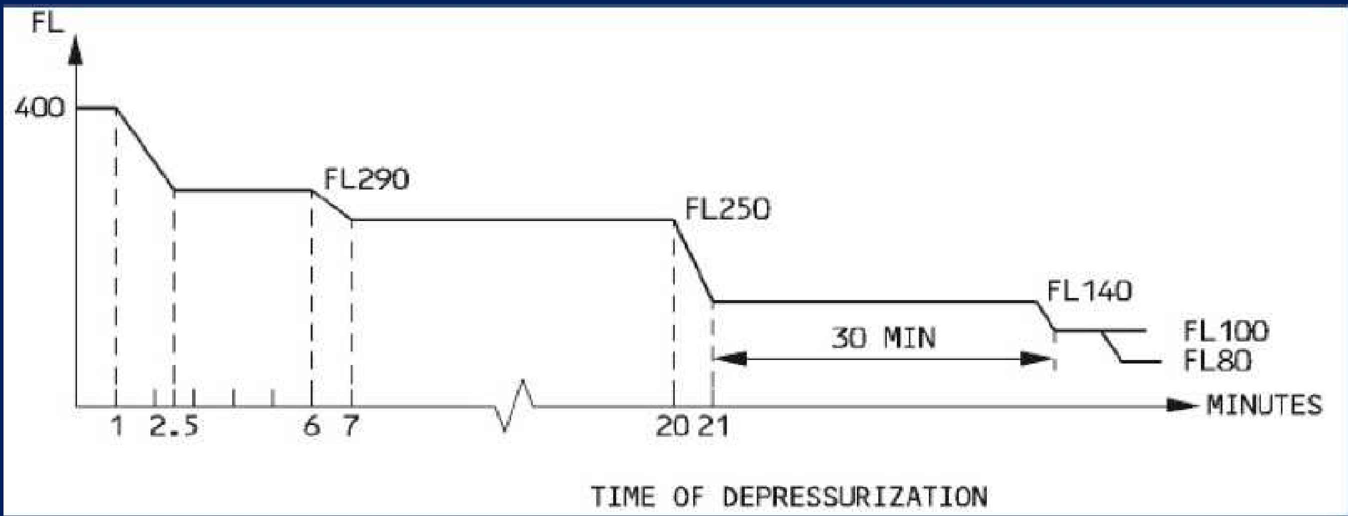


Figure 1. Depressurization critical descent profile (22 minutes O_2 chemical system)

As a result of this assessment you have to deliver:

- A **single pdf** file with an assessment report including all steps in the calculations that led to your solution and the rationales and assumptions that endorse it.
- The operational chart resulting from your study in annex to the assessment report. You can upload it as jpg, png or pdf.
- Both files must be uploaded in the link provided in ATENEA, within a zip file, before January 20th 2014 8h00 (Barcelona local time).
- Use the following file name convention: *OPS-RA_Surname1-Surname2.xxx* where *xxx* is the file extension of your files (pdf, png, zip...) and *Surname1-2* is the first family name of the two components of the group.

[2] http://inkscape.org
[3] http://wwww.gimp.org

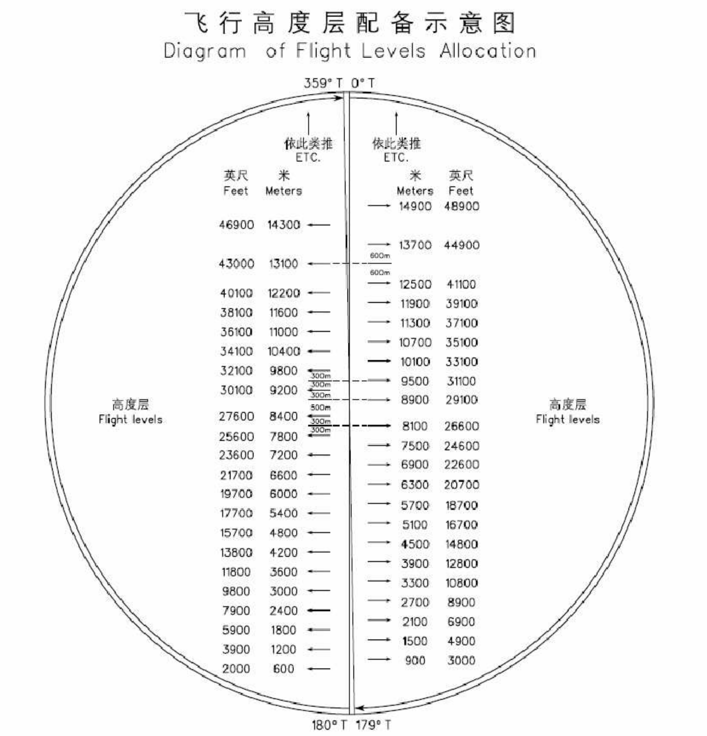


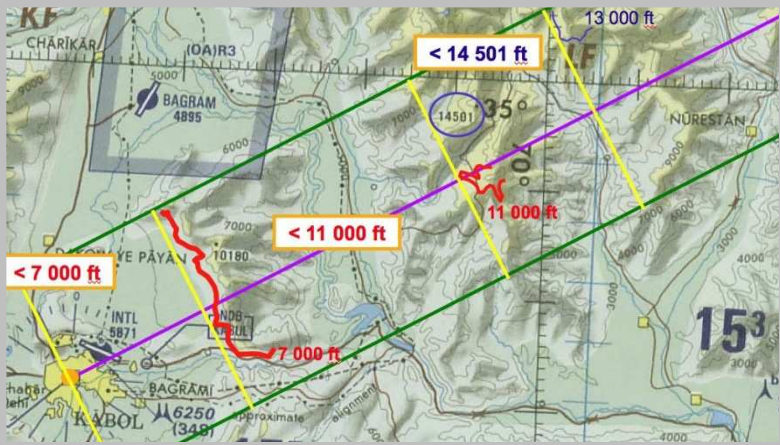
Figure 2. Chinese Flight Allocation System

Some guidelines to follow are:

1. Draw the route over the topographic chart using the image editor software.
2. Draw the obstacle assessment corridor using the image editor software.
3. Determine the obstacle profile along the nominal route (see guidelines of Figure3) and add the minimum obstacle clearance altitude to all elevations of the profile.
4. Considering the depressurization critical profile (Figure 1) and the aircraft performance given in annex to this document, determine your particular depressurization profile indicating the true[5] altitude as a function of the distance flown. Remember that the obtained profile (in time!) must be always at or below the critical profile of Figure 1.
5. In light of previous results, determine the non-return point(s) along the route.
6. If one or more route diversions are needed draw the new diversion route in the topographic map and assess the descent and obstacle clearance as done before.
7. Define all the needed operational routes to reach the en-route alternative airports (remember to use always VOR radials or NDB courses).
8. Define the operational vertical flight profile that will be finally published in the chart trying to minimize the altitude changes whenever is possible and remaining always at or below the critical profile of Figure 1. Define the descent points as distances to/from radionavigation aids or navigation fixes.
9. Proceed in a similar way for the one engine out procedure by using the drift-down flight path profile given as a fish-bone graph in the annex of this document.

[5] Recall that the barometric altitude, as sensed in the aircraft is calibrated to ISA conditions. Therefore, any temperature deviation from this standard will incur with differences between the barometric and true altitudes, these altitudes are already given in the annexed performance tables

A recommended procedure to assess the obstacles in your route is explained as follows:



1. Divide the route into several segments between two iso-level curves.
2. A variable segment length is recommended depending on the changes of terrain elevation. For terrain changing abruptly you may need shorter segment lengths. For more homogeneous terrain you can use longer segments.
3. For each segment identify the highest terrain elevation:
   a. when a spot elevation is present inside the segment, retain the this spot elevation as long as it is the highest elevation within the segment.
   b. when no such a spot elevation is present retain, the next highest iso-level curve.

In this example three segments are drawn. The first one (over Kabul city) is rather short because the elevation increases rapidly. The second one is longer because no big changes in elevation are found, while the third one is short again due to high peaks in the region. For the first and second segments no significant spot elevations are found. Therefore, the next highest iso-level curve of the segment is retained. For the first segment this curve is at 7000 ft (meaning that all elevations of this segment will be always below 7000ft). For the second segment it is at 11000ft. Finally, for the third segment a significant peak is found at 14501ft being the highest elevation within this segment. Therefore, this elevation is retained as the limiting elevation for the third segment.

Figure 3. Guidelines to assess the obstacles along your route