A COMMON EUROPEAN TRANSITION ALTITUDE

AN ATC PERSPECTIVE

LIST OF ACRONYMS

ACC	Area Control Centre
ANT	Airspace and Navigation Team
APDSG	ATM Procedures Development Sub-Group
ATC	Air traffic control
ATCO	Air traffic control officer
ATIS	Automatic Terminal Information System
ATS	Air traffic services
BARONAV	Navigation providing the vertical element
CAA	Civil Aviation Authority
DCPC	Direct controller pilot communications
ENR WG	Enroute Working Group
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Airline Pilots Associations
IFR	Instrument flight rules
ISA	ICAO Standard Atmosphere
Mode C	Transponder mode replying encoded altitude information
QFE	Atmospheric pressure at aerodrome elevation
QNE	Altimeter setting for ISA
QNH	Altimeter setting to obtain elevation when on the ground
RNAV	Area navigation
SID	Standard instrument departure
STAR	Standard instrument arrival
TA	Transition altitude
TL	Transition level
TMA	Terminal Control Area
VFR	Visual flight rules

EXECUTIVE SUMMARY

The mission of the EUROCONTROL Agency is a single sky for Europe. There are a number of initiatives underway intended to achieve that goal.

This report examines the desirability of implementing a common transition altitude.
A parallel study was completed to also examine this issue from the perspective of flight crews who operate within the European environment.
That study conclusively recommended that a common transition altitude should be implemented.

This report examines the same issues from the air traffic control perspective.

There are safety risks inherent in the current structure, which need mitigation. The overall risk to safety is that the current multiplicity of transition altitudes makes both the air traffic management and the flight operations environments needlessly complex and varied. Some of the notable risks are explained in Section 3.

The implementation of a common transition altitude is not a complex task but, like any change, it will take some effort and the willingness of the participants to make it happen. A common transition altitude will be a stepping stone toward the harmonisation of the European sky.

In States where terrain height is relatively low and uniform, a low transition altitude does not pose a direct safety risk of a terrain collision accident. The other risks resulting from of a lack of harmonisation of procedures across the Region remain. Low transition altitudes in the 5000 ft range or lower are not adaptable for common application in all European States.

A medium range transition altitude in the 10000 ft range will mitigate some safety risks in most European States but, again, cannot be commonly applied across the European Region.

A high transition altitude presents all of the advantages of a medium altitude and can be commonly applied. A high transition altitude will also accommodate future airspace strategy changes better.

For the reasons noted in this report the implementation of a common transition altitude should be pursued.

1. INTRODUCTION

The Eurocontrol Agency ANS Safety Policy states that: "The Agency has safety excellence as a core element of its mission and will assess all safety implications in order to ensure that:

- **Safety is given the highest priority**
- **Risks of an aircraft accident are minimized as far as reasonably practicable.**

1.1 The selection of transition altitudes by individual States and aerodromes within European airspace has evolved over time. It would be speculative to identify the reasons for the multiplicity of transition altitudes currently in use. Whether altitudes were chosen because of selective interpretations of ICAO documents, the convenience of service providers or other reasons is now somewhat irrelevant. Memories have faded and people have moved on.

The fact is that the situation which now exists is a fractionalised patchwork which can be categorised as safety critical.

1.2 ANT/22 16-18 May 2000 decided that the desirability/requirement for a common transition altitude for the ICAO EUR Region should be investigated and recommended upon.

1.3 APDSG/28 (Sept 25-27 2001) agreed with the ENR WG recommendation to select the area of Benelux, Germany and Denmark for simulation and also agreed to test 3 values for common transition altitudes: 5000 ft, 10000 ft and 16000 ft. These values were intended to represent a low, a medium and a high transition altitude and not as single choices.

1.4 At the request of Skyguide it was later agreed to also compare 18000 ft with 16000 ft.

1.5 ANT/27 (27 Feb 1 Mar 2002) supported the invitation of the selected States to participate in the fast-time simulation process. Invitations were sent on Mar 22 2002.

1.6 APDSG/30 (23-25 Apr 2002) agreed to change the high transition altitude value to be simulated from 16000 ft to 18000 ft.

2. REFERENCES

- ICAO PANS- ATM Doc 4444 ATM/501, Chapter 4 4.10 and 8.5.4.2
- ICAO PANS OPS Doc 8168-OPS/611, Volume I, Part VI, Chapter I
- ICAO ATS Planning Manual -Doc 9426-AN/924 , Part II, Section 5, Chapter I
- ICAO Annex 2, Chapter 4, Para 4.7
- Towards A Common Transition Altitude. A Flight Deck Perspective
- UK CAA Level Bust Working Group Study
- State AIP's
- FAA, FAR 91.121

3. GENERAL CONCEPTS

3.1 For this discussion there are four concepts to consider on altimeter use in the context of Transition Altitude (TA) and Transition Level (TL).

- **Vertical separation between aircraft**
- **Terrain clearance**
- **Flight operations**
- **ATC operations**

3.2 Vertical Separation

3.2.1 By assigning different altitudes or flight levels to aircraft in conflict, ATC provides vertical separation. The provision of vertical separation between aircraft by ATC is based on the precept that aircraft in the same airspace will be operating on a common altimeter setting and will maintain the assigned altitudes/flight levels within the required tolerances.

3.2.2 The ICAO requirement for Mode C altitude display is +- 300 ft and States may lower that to not below 200 ft.

3.2.3 Common altimeter settings may be achieved by having all aircraft operating in a given airspace on a common QNH provided by ATS agencies via a number of means or by flying on a standard altimeter setting, QNE. The latter is achieved by establishing a transition altitude above which only the QNE setting will be used. This is a sound concept which assures a common altimeter setting over a wide area without the need for changes of settings or updates from ATS.

This remains true regardless of the transition altitude value.

The safety issue with this concept lies in the varied applications.

3.3 Terrain Clearance

3.3.1 Except while under radar vectors by ATC, the pilot is responsible for maintaining adequate terrain clearance. Ref PANS- ATM, Doc 4444 ATM/501, Chapter 8- 8.6.5.2
In airspace where transition altitudes have been established sufficiently high enough to assure adequate clearance from all possible obstacle conflicts, flying at the minimum Flight Level on the standard QNE altimeter setting does not present a safety risk.
However, where transition altitudes have been established at relatively low altitudes and terrain clearance is a factor, as is the case at may EUR Region aerodromes, there can be a significant safety risk.

3.3.2 Altimeters are subject to a number of systemic errors, which require correction factors to be applied to determine adequate terrain clearance. The only time that an altimeter will indicate the true altitude of an aircraft at all levels is when ICAO Standard Atmosphere (ISA) conditions exist. When flying at a flight level in an area of low pressure, the true altitude will always be lower than the corresponding FL. Conversely, when flying in an area of high pressure the true altitude will be higher than indicated.

3.3.3 The altimeter errors may be significant in themselves and may also, under certain conditions, be cumulative. This situation can represent a significant difference between the indicated altitude and the actual altitude. The pressure error combined with cold temperature error can produce an error of up to 2000 ft. Mountain waves, in combination with very low temperatures, may result in an altimeter over reading by as much as 3000 ft.

3.3.4 The altimeter corrections required to determine the true altitude from which the pilot can determine actual height above terrain can be complex enough and time consuming to be error prone or mis-applied. This could lead to either a loss of vertical separation with other aircraft or a loss of pilot situation awareness resulting in a collision with terrain.
An example of this potential risk can be illustrated using a specific location and sample conditions, as follows:

<u>Graz, Austria</u>
Aerodrome elevation 1115 ft
Transition altitude 4000 ft
Minimum sector altitude NW 7600 ft
Low QNH of 979 hPa
Wind speed 20 kts
Temperature -10*C & assuming standard lapse rate
Under these conditions assuming QNE 1013.2 is set climbing through the TA at 4000 ft, the true altitude would be 1020 ft lower than the indicated FL.
The low temperature will add a further altimeter error of 105 ft.
The wind speed will compound the error by 53 ft.
Altimeter instruments are calibrated to a tolerance of +- 60 ft.
The total combined error could therefore total **<u>1238 ft.</u>**

If no altimeter correction factors are added for the given conditions an aircraft in this situation flying at an indicated FL80 over this terrain could actually be at a true altitude of 6762 ft, **<u>almost 1000 ft below the MSA</u>**.

The MILGO ONE GOLF Standard Instrument Departure (SID) chart at attachment D shows the potential trap for the unwary. The minimum altitude crossing the fix marked D18 GRZ is 8000 ft. To meet this minimum altitude and conform to the level for direction of flight the minimum acceptable FL under the example conditions would be FL 100.

Under these same conditions, if the aircraft operated on the local QNH to a higher TA of 10000 ft or higher for example, the risk of a terrain accident due to an uncorrected pressure differential error of 1020 ft would be eliminated.

Higher than ISA pressures and temperatures also cause erroneous altimeter readings which are less critical for obstacle clearance but more susceptible to level busts. .

In the event of an emergency turn back in marginal weather the flight crew is under intense pressure.
Altitude/flight level conversions and corrections are added complexity factors which can induce errors.

3.4 Flight Operations

3.4.1 The multiplicity of transition altitudes in the EUR Region airspace has created operational difficulties and raised safety concerns for flight crews. The numerous vertical situation awareness changes necessary when transiting from one TA to another in adjoining airspace and the changes from altitude to flight level and vice versa during climb and descent, often at critical times in the flight profile, are error inducing.

3.4.2 The impact on flight operations has been the subject of a separate study titled **"Towards A Common Transition Altitude. A Flight Deck Perspective"** conducted for EUROCONTROL.

3.4.3 The conclusions of that report clearly recommend not only a higher transition altitude than most current ones, but also that the higher transition altitude should be commonly applied within the EUR airspace. The report also identifies the significant safety risks of the current structure.

3.4.4 The issue of level busts was recently studied by the UK CAA. The Level Bust Working Group for this study analysed 626 reported level busts and found that 68 (10.9%) of these were caused by altimeter mis-setting. Of these, a full 58 were due to either QNH or QNE not being set at the designated point.
Such errors can of course happen at any altitude but are more critical at lower altitudes where obstacle clearance is a factor and in TMAs where traffic is normally more intense.

3.4.5 Some military agencies still use the QFE altimeter setting for final approach.
In the event of a missed approach and a second approach, a low TA below the missed approach level off FL entails 6 changes of altimeter settings (initial QNE to QNH to QFE to QNH to QNE back to QNH and QFE) and 6 corresponding altitude awareness changes during the most intense workload period of a flight profile. An emergency turn back presents similar if not more critical problems. With possibly some rare exceptions civil operators have discontinued the use of QFE procedures. Accordingly, consideration should be given cease the use of QFE for all civil aviation.

3.4.6 As air carriers continue to expand their sphere of operations it is more imperative that common standards and procedures are used. Flight crews unfamiliar with the European environment are at greater risk.

3.4.7 IFALPA is clearly supportive of establishing a common TA. An excerpt from IFALPA policy states: “This diversity [of transition altitudes] is operationally unsatisfactory for IFALPA as it gives rise to serious operational problems… IFALPA recommends the establishment of a common transition altitude within each state and, where possible, within each ICAO region.”

3.5 ATC Operations

3.5.1 The QNE altimeter setting ensures all aircraft in the airspace at and above the Transition Level (TL) are on the same setting. All altimeter errors resulting from non-standard pressure and temperature will therefore be common to all aircraft occupying the same relative airspace. The only potential error remaining will be limited to the accepted calibration tolerance.

3.5.2 From an ATC viewpoint this is clearly advantageous in providing the required vertical separation. No changes or updates of altimeter settings are required for aircraft cruising at and above the TL. Only aircraft operating below that level or descending through it need to be provided with the current QNH setting.

This also holds true regardless of the TL value.

3.5.3 The issue now becomes one of determining the impact on ATC units of changing the TA.

4. CURRENT STATUS OF TA/TL IN SIMULATION AREA

4.1 Belgium

The TA for all of Brussels FIR is set at 4500 ft above mean sea level (AMSL).
The TL is variable and determined by ATC depending on QNH changes, and is adjusted accordingly.
The TL is changed in 500 ft increments in accordance with QNH bands ranging from 14.9 hPa to 19.9 hPa.

4.2 The Netherlands

The TA for the whole FIR is set at 3000 ft AMSL.
The TL is variable in 1000 ft increments and determined by ATC based on QNH.

4.3 Denmark

The TA for the whole FIR is set at 3000 ft AMSL except for the Copenhagen Area where it is set at 5000 ft AMSL.
The TL is variable by ATC based on QNH.
The TL is changed in 1000 ft increments using QNH bands of 34 to 36 hPa

4.4 Germany

The TA is common to all FIRs, set at 5000 ft AMSL
The TL is variable by ATC based on QNH.

4.5 Luxembourg TMA

The TA is similar to Belgium at 4500 ft AMSL.
The TL is variable by ATC based on QNH.

4.6 Jurisdictions which use the 500 ft incremental movement of the TL do not always provide a 1000 ft transition layer between the TA and the TL. A common application should be adopted to do so in all cases.

5. ICAO REQUIREMENTS

5.1 ICAO Doc 4444

ICAO PANS- ATM, Doc 4444, Chapter 4, 4.10.4.5 mandates that: "*A QNH altimeter setting **shall** be included in the descent clearance when first cleared to an altitude below the transition level, in approach clearances or clearances to enter the traffic circuit, and in taxi clearances for departing aircraft, **except** when it is known that the aircraft has already received the information*". (emphasis for illustration-not in original text)

This clearly establishes the requirement for the first ATC unit which issues a descent clearance to an altitude to also issue the appropriate QNH setting. The majority of EUR States provide descent clearances to altitudes through approach control facilities. Higher TA's may increase the participation of en-route ACCs in this role.

Chapter 4, 4.10.4.2 states: " *Flight information centres and **ACCs shall** have available for transmission to aircraft on request an appropriate number of QNH reports or forecast pressures for the FIRs and control areas for which they are responsible, and for those adjacent."* (emphasis for illustration-not in original text)

This establishes the requirement for ATS provider units to have QNH information available not only within their respective airspace but that adjacent to their own.

5.2 ICAO Doc 9426

The **ICAO AIR TRAFFIC SERVICES PLANNING MANUAL, Doc 9426 Chapter 2 Appendix D** specifies, in part, that: "*ATIS messages **should** contain …. altimeter setting(s)"* (emphasis not in original text)

This allows the ATC units to provide the required QNH setting by other means than DCPC and could be further utilized to relieve QNH provision workload shifted by a higher TA.

5.3 ICAO Doc 8168

5.3.1 **ICAO PANS- OPS, Doc 8168, Vol I, Part VI, Introduction d)** states, in part: " d) *The adequacy of terrain clearance during any phase of a flight may be maintained in any of several ways, depending on the facilities available in a particular area, the recommended methods in the order of preference being:*

1) the use of current QNH reports from an adequate network of QNH reporting stations;

2) the use of such QNH reports as are available combined with other meteorological information such as forecast lowest mean sea level pressure for the route or portions thereof; and

3) where relevant current information is not available, the use of values of the lowest altitudes of flight levels, derived from meteorological data.

Flight crews are dependent on the availability of QNH reports to adequately determine terrain clearance.

5.3.2 **PANS – OPS, Part VI, Chapter, I, 1.1.2 Transition Altitude** specifies the requirements for establishing transition altitudes as follows:

1.1.2.1 A transition altitude shall normally be specified for each aerodrome by the State in which the aerodrome is located.

1.1.2.1.1 Where two or more closely spaced aerodromes are so located as to require co-ordinated procedures, a common transition altitude shall be established. This common transition altitude shall be the highest of the transition altitudes that would result for the aerodromes if separately considered.

1.1.2.1.2 As far as possible a common transition altitude should be established:

a) for groups of aerodromes of a State or all aerodromes of that state;

b) on the basis of an agreement, for aerodromes of adjacent States, States of the same flight information region, of two or more adjacent flight information regions or one ICAO region; and

c) for aerodromes of two or more ICAO regions when agreement can be obtained between these regions.

1.1.2.1.3 The height above the aerodrome of the transition altitude shall be as low as possible but normally not less than 900 m (3000 ft).

1.1.2.1.4 The calculated height of the transition altitude shall be rounded up to the next full 300 m (1000 ft).

1.1.2.2 ***Notwithstanding the provisions of 1.1.2.1*** *a transition altitude may be established for a specific area, when so determined on the basis of regional air navigation agreements*. (emphasis not in original text)

1.1.2.2 Transition altitudes shall be published in aeronautical information publications and shown on the appropriate charts.

5.4 Compliance with the ICAO provisions

Not all States are in compliance with the above ICAO requirements.

19 EUR States have two or more transition altitudes for the same aerodrome depending on the departure/arrival direction. Some have up to 4 at the same aerodrome. One EUR State has 118 different TA values for the airports listed.

One State uses confusing terminology – ***Transition Altitude 3000m QNH. Remarks: Transition height (TH) by QFE is used instead of transition altitude (TA).*** **For the same airport, the STAR chart showed*:*** ***Transition Altitude 1310m*** **and the ILS approach chart showed a different TA:** ***Transition Altitude 1500*** **(with no unit of measurement)**

A number of States have not co-ordinated the TA with that of closely adjacent aerodromes. Numerous closely spaced aerodromes have different TAs.

Numerous States have not rounded off the TA value to a full 300m (1000 ft) and have established TAs below 900 m (3000 ft). TAs in the EUR Region range from 1570 ft to 16000 ft.

28 States have established a single TA in their airspace. 20 have not.

Some States have not published TAs in their AIP but have approach charts with the remark: ***TA by ATC.***

6 CONCLUSIONS

6.1 Availability of QNH values in ACCs.

The ICAO requirements of Doc 4444 (PANS-ATM), as noted in paragraph 5.1 above clearly make it incumbent on ATS providers not only to issue the QNH setting when clearing an aircraft below the TL but also make it mandatory to have QNH values available on demand in the ACCs.

6.2 It is apparent that some States have taken differing interpretations of the ICAO requirements; have been selective in their partial implementations of the requirements, or chose to implement other procedures based on their own requirements.

6.3 The uncoordinated establishment of different TAs at adjacent aerodromes is not only contrary to ICAO requirements but presents safety risks.

6.4 The notwithstanding clause of ICAO PANS-OPS, Part VI, Chapter I, para 1.1.2.2 noted in para 5.4 above relieves States from the requirements of **all of 1.1.2.1** (same para above) and allows the flexibility for the establishment of a common TA at higher altitudes by regional agreements such as those in the Far East, where 11000 ft is the common TA, and North America, where it is 18000 ft.

No such agreement exists in the EUR region today.

7 ATC ISSUES

7.1 Departures

Departing aircraft from any aerodrome use the local QNH as provided by ATS agencies or as otherwise obtained where no ATS facilities are present.
Current QNH delivery procedures for departures would therefore be compatible with higher TAs. No changes from current procedures would be anticipated for departures.

7.2 En-route

7.2.1 For aircraft cruising at altitudes, a current and proximate QNH setting is needed not only for terrain clearance awareness but also for vertical separation purposes. These aircraft need to be provided with updated QNH values as the flight progresses en-route.
This presents a fundamental change in procedures where TAs are low and may result in a transfer of workload to ACC sectors if the chosen TA lies within their airspace jurisdiction.

For such en-route flights some States provide area altimeters derived from the lowest QNH value of designated reporting stations within the defined area. For example, Denmark has 2 such areas; Belgium 1, The Netherlands 4 and the UK has 21.
Germany does not use the area altimeter concept. Instead, the QNH value for the nearest aerodrome to the route of flight is used.

7.2.2 The merit of using the area altimeter concept is arguable. It can be argued positively in that all aircraft flying at altitudes within that defined airspace will be on a common altimeter setting therefore any vertical separation provided will be based on the same altimeter reference value. This is in effect equivalent to the QNE concept on a smaller scale.

7.2.3 The negative aspect is that some of these areas are approximately 180 nm long making the accuracy of the altimeter setting suspect because pressure changes over that distance may, in some cases, be significant enough to make terrain reference somewhat inaccurate.
It must be emphasised that although the indicated altitude may be inaccurate it is not unsafe in this case because, by using the lowest QNH setting within the defined area, any pressure errors will be on the high side therefore terrain clearance will be greater than indicated.

The other negative is that the boundaries of these altimeter areas are defined by geographic co-ordinates and, although charted, may not be readily apparent to the pilot during flight. The safety risk here is that aircraft could arrive from adjacent altimeter areas at a common boundary point on substantially different altimeter settings.

As an example, Belgium uses one area altimeter for all of Brussels FIR based on the lowest QNH setting of 13 reporting stations. The western edge of the Brussels FIR and the Amsterdam regional altimeter area share a common boundary. It is therefore possible for two aircraft to be in close proximity at this boundary with one flying on the Luxembourg altimeter setting, if it is the lowest QNH of the Brussels FIR reporting stations, and the other on the Amsterdam setting. These QNH settings could differ substantially.

7.2.4 In some States, arrivals and local flights at an aerodrome use the local QNH provided and transiting flights below the TL and outside the local airspace use the area QNH. Concerns have been raised by ATC providers that this presents a potential safety risk for more aircraft operating in close proximity to the local airspace if the TA is raised. It can be argued that the use of area altimeters already imposes an unnecessary safety risk as noted above in 7.2.3. In fact a greater risk than would be present if all aircraft operated on the closest station altimeter, in which case any QNH differences would be insignificant and well within the Mode C tolerance parameters previously noted.

7.2.5 Analysis of atmospheric pressure data provided by The Netherlands meteorology office for 2001 shows that the largest pressure difference between the 3 reporting stations of; EHAM, EHBK and EHGG, in all of 2001 was 14.7 hPa. On Dec 28 at 1700.
The largest average difference for the year was 10.1 hPa. Which would equate to an altitude difference of approximately 300 ft.
From this it can be seen that, on average, one altimeter update en-route between any of these three points would suffice to keep aircraft vertically separated well within the Mode C tolerance under normal conditions. It is reasonable to expect similar applications to be valid elsewhere. More frequent updates may be required in conditions of an abnormally steep pressure gradient. In areas prone to known microclimate influences, special attention to pressure changes would normally be required.

7.3 Arrivals

7.3.1 For the best flight profile, arriving jet aircraft ideally will initiate descent at a distance, in nautical miles, equal to three times the top of descent altitude plus or minus the wind component factor. This means that a jet aircraft at, for example, FL 330 will normally start descent at approximately 100 nm from destination assuming no wind component or ATC constraints.

7.3.2 Under the current airspace structure, the upper ACC sectors are generally above FL 195 or FL 245, depending on the jurisdiction. Since all current TLs are well below, no QNH settings are required from these sectors although they must have them available, for use in the event of an emergency descent.

7.3.3 The lower airspace en-route sectors in the current structure, again depending on the jurisdiction, are not normally involved with providing QNH settings unless requested, or required for emergency descents.

7.3.4 In the airspace selected for simulation, as well as the majority of EUR States, the provision of QNH settings is done primarily by Approach Control facilities. This can be provided by either DCPC or ATIS. The current TL is also provided at the same time by the same methods. Under normal operating procedures the flight crew will have already obtained this information from ATIS well before entering the TMA.

7.3.5 If the TA is raised to a medium or high altitude in the 10000 ft or 18000 ft range, the lower ACC en-route sectors will become more involved in the provision of altimeter settings.
Even with a high TA in the 18000 ft range only one altimeter setting, that of the destination aerodrome, needs to be issued since high level descending aircraft will be well within range at that point.
Any additional workload transfer will need to be measured and evaluated during simulation to determine the impact on the units affected.

8. AIRSPACE MANAGEMENT

8.1 TMA dimensions vary as much as TAs from one jurisdiction to another. Some aerodrome airspace have a single TMA with specified horizontal and vertical dimensions, some have 2 and some have 3 differing TMA areas. These designs are presumably intended to best accommodate the ATC providers in the work of handling the traffic load and patterns of the particular area.

Coincidentally they should also provide the users of that airspace with the most efficient and safe service possible.

8.2 As noted in section 4, the TL is adjusted in each case based on the QNH. When the QNH is equal to or higher than QNE, the lowest useable TL is the first level above the TA. This provides for a transition layer of a minimum of 1000 ft for controlled flights. Although, as noted in section 4 above, some jurisdictions change the TL in 500 ft increments and therefore do not always provide a 1000 ft transition layer between the TA and the TL. It would seem advisable to do so in all cases for commonality of procedures and for safety.
Whenever the QNH drops to a value below QNE the TL must be raised to the next level to maintain the 1000 ft transition layer. When the pressure drops further within the QNH bands selected the TL is again raised yet another level.

Each time the TL has to be raised means that a one thousand foot layer is lost to ATC and the users.
Conversely, when the QNH reaches the trigger value of 1051 hPa it is theoretically possible to gain one FL by using both the TA and the TL simultaneously while still having a transition layer of 1000 ft.

Analysis of the 24844 reported QHN entries for the Amsterdam station for the year 2001 shows the highest QNH value was 1040 hPa.

In a busy terminal area such as Amsterdam TMA 1 for example, with a minimum vectoring altitude of 2000 ft, a TA of 3000 ft and an airspace cap at FL95 this leaves a maximum potential of 8 usable combinations of altitudes/ FLs.
Anytime the QNH drops below 1014 hPa the TL must be raised to 5000 ft leaving only 7 available and when the QNH is 977 hPa or lower, only 6 remain available. The latter, although rare, represents a 25% loss of usable airspace within that TMA.

Based on the meteorological data reviewed for this report the Amsterdam TMA lost one level during 191 days in 2001.
TMAs capped at a lower altitude suffer an even greater proportional loss.

During a period of high demand this may become a factor in reducing capacity.

8.3 The loss of usable FLs holds true no matter how high the TA is set. If it is 10000 ft or 18000 ft or any other number there will be a corresponding loss when the QNH drops to the trigger values. The determination to be made is in what stratum this is the least disruptive to ATC and the users. The traffic distribution data reviewed shows that the loss of airspace in a terminal area, where the traffic is more intense and concentrated, would have a greater negative impact than at higher levels.

The traffic analysis shown at Attachments A, B and C of this report represents the peak day, peak hour traffic extracted from CFMU data for all of Belgium, Luxembourg, The Netherlands, Denmark and Germany combined. This occurred on Sept 7, 2001. From these numbers it can be determined that at a TA of 5000 ft 28 aircraft would have departed and remained at or below the TA and would therefore require some action from ATS for updating the altimeter setting.
With a 10000 ft TA the number of aircraft requiring en-route altimeter setting would have increased to 72, and finally, to 148 at a TA of 18000 ft.
It should be emphasised that this workload would be spread amongst all low en-route sectors of all FIRs combined, although it may not be evenly distributed.

8.4 SIDs and STARs were developed to take advantage of the capabilities of advanced airborne navigation systems. They allow more efficient use of terminal airspace and ATC capacity by reducing communications and standardising flight profiles.
Low TAs are incompatible with the intended objective of SIDs and STARs. The change from altitude reference to flight level reference at various points during either procedure introduces complexity, which in turn also induces errors.
A suitably higher TA would improve the efficiency and safety of these procedures by making all altimeter references to QNH for ATC, the flight crews and the airborne flight management systems. It would also avoid the loss of usable vertical airspace in a terminal area due to variable TLs as noted in 8.2 above.
The future introduction of precision area navigation procedures in both the horizontal and vertical plane will make it necessary to adjust TAs for their efficient implementation.

9. Conclusions

9.1 Below the TL the altimeter setting of a station close to the route of flight provides the better option for the combination of accurate altitude indications and a common reference for vertical separation to proximate aircraft. The validity of the area or regional altimeter concept should be reconsidered.

9.2 The logistics of providing en-route altimeter settings are not difficult and can be adapted to best suit the facility as long as the output is consistently applied. Experience in other jurisdictions using medium or high TA's has proven unproblematic. As an example, the North American systems (FAA and NAV CANADA) combined handled approximately 75 million flight operations in the year 2000 using a common TA of 18000 ft. The accepted procedure is to provide aircraft en-route below the TL with an altimeter setting from a source within 100 nm of the aircraft position and for controllers to issue the altimeter setting at least once while the aircraft is within the controller's area of jurisdiction.

The ECAC States, by comparison, handled approximately 8.5 million flight operations during the same period.

9.3 Higher TAs allow more efficient use of the available airspace and create the potential for capacity improvements in TMAs.

9.4 A common TA should facilitate the further development of common ATC procedures which should, in turn, permit more standardised flight operations procedures.

9.5 Flight safety would be enhanced with the implementation of a common TA by reducing the complexity; the confusion and the risk of error inherent in using non standardised procedures.

10. EVALUATION OF TRANSITION ALTITUDES

10.1 In order to conclude the best choice for a common TA it is necessary to compare the advantages and disadvantages of having first, a common TA, and then to similarly compare the sample low, medium and high altitudes selected for simulation evaluation.

10.2 Common TA

	Advantages		Disadvantages
1	ICAO recommended	1	Implementation of change for some ATC providers
2	IFALPA recommended	2	Training and adjustment period
3	Flight Deck study recommended	3	Temporary loss of ATCOs comfort zone with current familiarity
4	Common procedures reduce potential for error	4	Possible resources implications for implementation
5	Facilitates common approach design	5	Requires amendments to some State regulations
6	More compatible with RNAV/BARONAV procedures	6	Operations and publications amendments required to implement changes
7	Simplifies ATCOs adjustment and training to various airspace/sectors		
8	Simplifies publication of charts		
9	Facilitates national and international arrangements		
10	Proven record of safe application in North America of over 50 years and in other regions		
11	Facilitates integration of VFR/IFR altimeter setting procedures		
12	Facilitates integration with future changes in airspace structure and classification		
13	Reduced risk where adjacent airports use different TAs		
14	Eliminates the need for ATC to provide the TL information		
15	Overall improvement to flight safety		
16	Compatible with the EUROCONTROL Agency ANS Safety Policy		

10.3 **Low TA – 5000 ft**

	Advantages		Disadvantages
1	Already exists in some jurisdictions or locations	1	Only adequate for terrain clearance issues where terrain obstacles are relatively low
2	No change in procedures for some providers	2	Not compatible with SIDs/STARs design and application
3	Familiarity for some ATC providers, minor adjustment for others	3	Loss of valuable airspace in TMAs
		4	Not ideal for flight operations procedures
		5	Not easily compatible with changes in airspace structure or classification
		6	Mix of altitude and flight level references in TMA airspace
		7	Current VFR/IFR integration problems
		8	Exceptions needed to regional agreement
		9	Requires the application of altimeter correction factors for determining terrain clearance depending on location

10.4 **Medium TA – 10000 ft**

	Advantages		Disadvantages
1	Compatible with most SID/STAR designs and noise abatement procedures	1	All contras involved w/ changes – same as implementation of a common TA as in 10.2 above
2	More preferable for flight operations	2	Not high enough for terrain issues in all States therefore cannot be used as common TA for all States
3	Acceptable to IFALPA	3	Some TMA caps are above this altitude
4	Minimises terrain clearance issues in most States	4	Transfer of workload for most ATS providers
5	Eliminates TA/TL reference mix in most TMAs for flight crews and ATCOs	5	Exceptions still needed to regional agreement
6	More compatible for VFR/IFR integration	6	
7	Facilitates airspace structure and classification changes more easily than lower TA		
8	No loss of usable airspace in most TMAs		
9	No adjustments of TL necessary in the majority of TMAs		
9	Constant vectoring parameters		
10	Above most TMA caps		
11	No application of altimeter corrections in most areas		

10.5 **High TA – 18000 ft**

	Advantages		Disadvantages
1	Common with NAM structure	1	More aircraft need QNH setting
2	More adaptable to airspace structure/classification changes	2	Additional workload for ACCs
3	Eliminates terrain clearance issues in all States	3	All change related issues previously noted
4	Facilitates future SID/STAR, RNAV/BARONAV design and implementation	4	Potential complexity with airspace division at FL195 will require further study
5	Adaptable as common TA for all ECAC		
6	Acceptable for flight operations		
7	Acceptable to IFALPA		
8	Most facilitates regional agreement		
9	No mix of TA/TL reference in lower airspace		
10	No application of altimeter correction for terrain clearance		

11 CONCLUSIONS

11.1 The establishment of a common TA for ECAC States and the EUR Region is a fundamental element in achieving the goal of a unified sky and the safety policy of reducing risks to the greatest degree practicable. Aviation history has proven conclusively, and too often tragically, that the standardisation of procedures and adherence to those procedures reduces the probability of error.

The current multiplicity of TAs is contrary to both the goals of the agency and to good operating practice.

11.2 ATC providers, as is human nature, grow comfortable with what they are most familiar. It is natural to resist change if there is no apparent benefit for those involved in implementing the change.

11.3 Systems which contain potential risk should not be perpetuated for internal structural reasons.

The challenge for the ATC service providers and the State regulators will be willingness to invest the effort necessary to implement this change for the single objective of improving flight safety.

12 RECOMMENDATIONS

12.1 The study " Towards A Common Transition Altitude – A Flight Deck Perspective" previously noted in 3.4.2 conclusively determined that a low TA is not conducive to flight safety.
The ATC perspective also supports that finding.

There are compelling safety reasons for higher TAs. There are also substantial ATM operational benefits, not only in the current environment, but also in the preparation for structural changes which will inevitably come with evolving technology.

12.2 A medium altitude TA provides significant improvements in safety. The 10000 ft example is preferable from a flight operations perspective. It also provides a number of benefits to ATM operations, capacity and airspace structure elements.

12.3 A high altitude TA is also acceptable from a flight operations perspective. It provides most of the flight operations benefits of a medium altitude.

From an ATM perspective it will facilitate structural airspace changes and classification changes more readily than the others.

A high TA will be more adaptable to procedural changes designed to accommodate the evolution of more efficient and economical future RNAV/BARONAV flight profiles.

The implementation of a high TA would allow a full EUR regional agreement without exceptions for those States with high terrain.

If accepted, a high TA could therefore be implemented uniformly for all the ECAC States and the EUR Region.

12.4 The implementation of a common TA is therefore recommended.

12.5 The selection of the TA value should be determined on the outcome of the simulation and with the concurrence of the stakeholders.

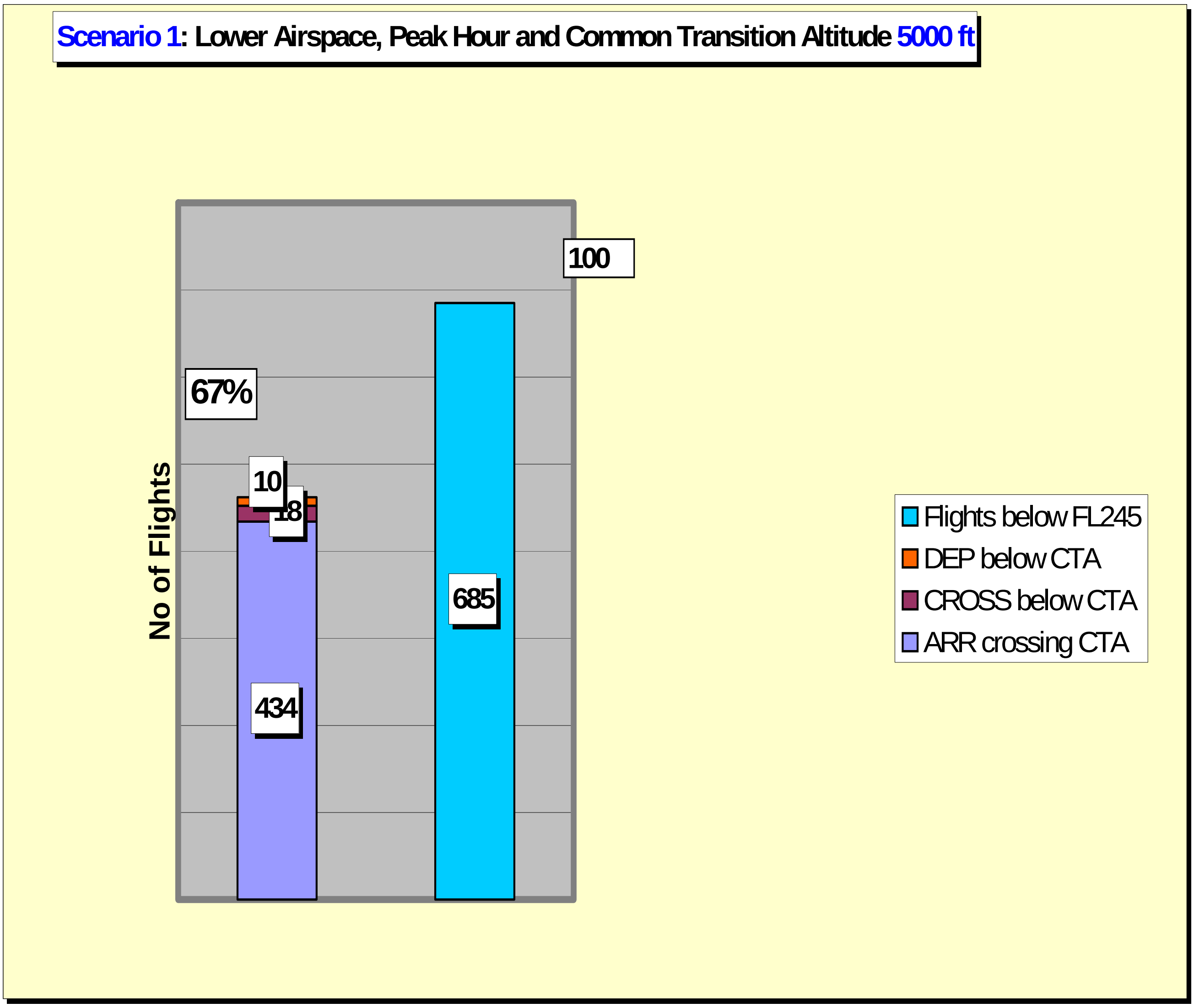
Attachment A

Lower Airspace, Peak Hour and Common Transition Altitude 5000

Peak Hour (traffic sample from CFMU database 7 Sept 2001)	**1500-1559**
Number of flights during the peak hour and below FL245	685
Number of arrivals during the peak hour	437

Scenario 1 - Common Transition Altitude 5000ft

TOTAL number of flights during the *peak hour* and below FL245	**685**	**100%**	Flights below 245
Number of ARRIVALS which are crossing FL050 during the *peak hour*	434		ARR crossing CTA
CROSSING traffic below FL050 during the *peak hour*	18		CROSS below CTA
DEPARTURE during the peak hour, CFL below FL050	10		DEP below CTA
Total number of flights which need the QNH info (ARR+CROSS+DEP)	**462**	**67%**	Total



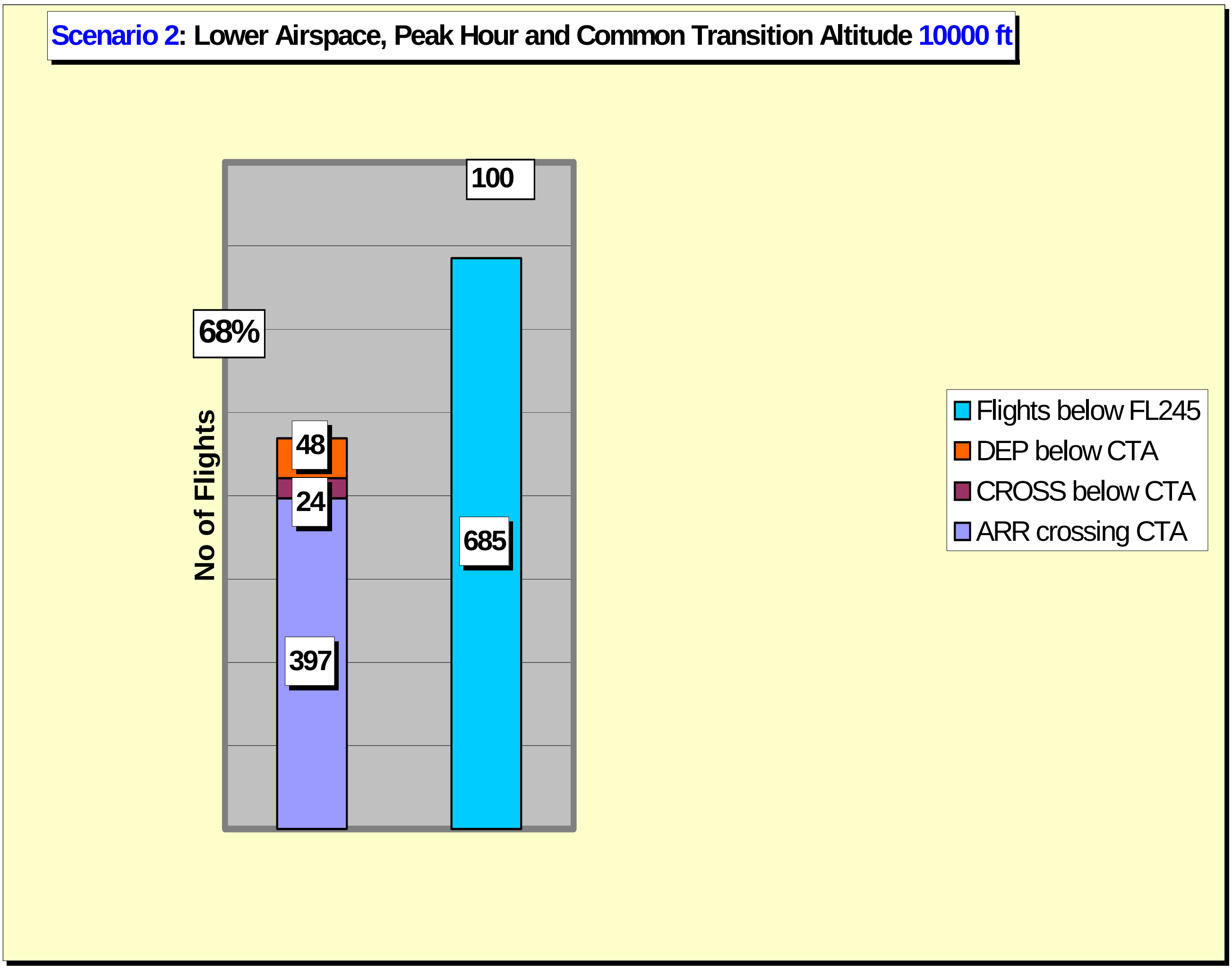
Attachment B

Lower Airspace, Peak Hour and Common Transition Altitude 10000 ft

Peak Hour (traffic sample from CFMU database 7 Sept 2001)	**1500-1559**
Number of flights during the peak hour and below FL245	685
Number of arrivals during the peak hour	437

Scenario 2 - Common Transition Altitude 10000ft

TOTAL number of flights during the *peak hour* and below FL245	**685**	**100%**	Flights below 245
Number of ARRIVALS which are crossing FL100 during the *peak hour*	397		ARR crossing CTA
CROSSING traffic below FL100 during the *peak hour*	24		CROSS below CTA
DEPARTURE during the peak hour, CFL below FL100	48		DEP below CTA
Total number of flights which need the QNH info (ARR+CROSS+DEP)	**469**	**68%**	Total



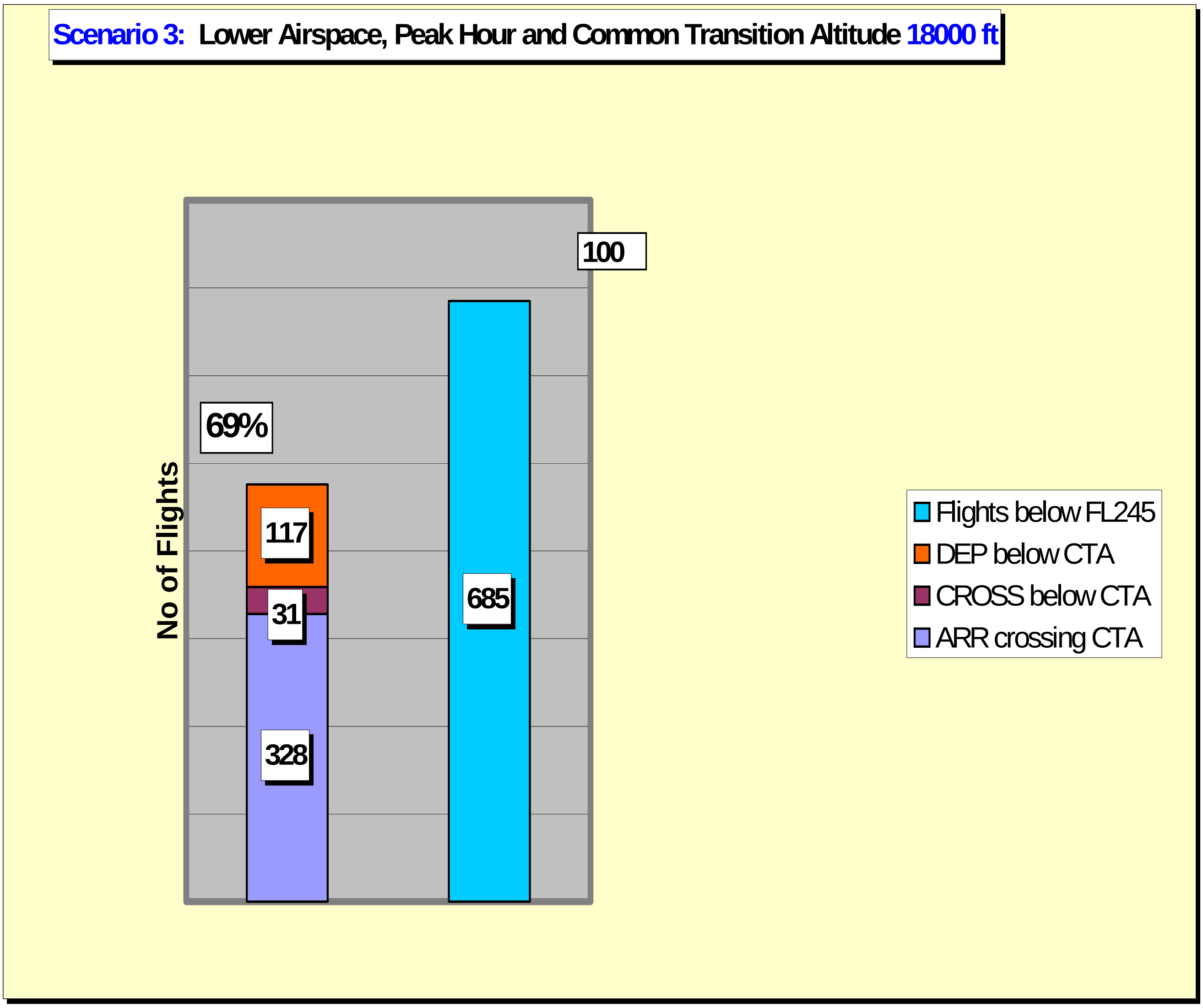
Attachment C

Lower Airspace, Peak Hour and Common Transition Altitude 18000 ft

Peak Hour (traffic sample from CFMU database 7 Sept 2001)	**1500-1559**
Number of flights during the peak hour and below FL245	685
Number of arrivals during the peak hour	437

Scenario 3 - Common Transition Altitude 18000ft

TOTAL number of flights during the *peak hour* and below FL245	**685**	**100%**	Flights below 245
Number of ARRIVALS which are crossing FL180 during the *peak hour*	328		ARR crossing CTA
CROSSING traffic below FL180 during the *peak hour*	31		CROSS below CTA
DEPARTURE during the peak hour, CFL below FL180	117		DEP below CTA
Total number of flights which need the QNH info (ARR+CROSS+DEP)	**476**	**69%**	Total



Attachment D

Graz SID