Flight Operations Briefing Notes

Supplementary Techniques

Preventing Altitude Deviations / Level Busts

I Introduction

Altitude deviations (also referred to as level busts) may result in substantial loss of vertical separation and/or horizontal separation, which could cause a midair collision.

Traffic avoidance maneuvers, if required, usually result in injuries to passengers and crewmembers (particularly to cabin attendants).

This **Flight Operations Briefing Note** provides an overview of the factors involved in altitude deviations.

This document can be used for stand-alone reading or as the basis for the development of an airline's altitude awareness program.

II Statistical Data

An analysis reveals that (source - U.S. FAA and US Airways) :

- Approximately 70 % of altitude deviations are the result of a breakdown in the pilot/controller communication loop; and,
- Nearly 40 % of altitude deviation events affect the critical pair constituted by FL 100 / FL 110 (or 10 000 ft / 11 000 ft).

A study performed by the UK CAA, between 1995 and 1997, showed that 50 % of altitude deviations take place below 8000 ft, usually as the result of the mis-understanding of the altitude restrictions applicable during departure (SID) or approach (STAR).

A survey indicates that, worldwide (source – Eurocontrol) :

- Once every 30 minutes, an aircraft is busting its cleared altitude / flight level; and,
- Each day, a loss of separation results in involved aircraft passing within a mile from each other.

The distribution of level bust events by flight phase is provided below (source - British Airways, Eurocontrol and IATA STEADES – rounded figures) :

- Climb : 60 % - mostly caused by late altitude clearances;
- Cruise : 10 % - mostly caused by turbulence / windshear or autopilot operation;
- Descent : 30 %.

III Defining an Altitude Deviation (Level Bust)

An altitude deviation (level bust) is defined by regulations as an unauthorized deviation from the assigned altitude (or flight level) equal to or greater than 300 ft (200 ft in RVSM airspace).

This also includes the failure to capture the assigned altitude / flight level (i.e., overshoot or undershoot of the cleared altitude / flight level).

Altitude deviations may result in :

- A loss of separation;
- A midair collision; or,
- A CFIT event.

IV Operational and Human Factors Involved in Altitude Deviations

Altitude deviations always are the result of a breakdown in either:

- The pilot / system interface :
  - Altimeter setting, use of autopilot, monitoring of instruments and displays (e.g., undetected system faults);
- The pilot / controller interface :
  - Communication loop; or,
- The PF / PNF interface :
  - Task-sharing, call-outs, cross-check and back-up.

Table 1 summarizes and ranks the main operational factors observed in altitude deviations / level busts.

Operational Factors	% of Events
Flight Management / Monitoring	25 - 40
Air Traffic Management / Control	20 - 30
Weather	15 - 20
Auto Flight System	10 – 20
Response to TCAS / ACAS TA or RA	10
Miscellaneous	5 - 10

(Source – UK CAA / Eurocontrol / IATA STEADES – 1997-2004)

Table 1

Factors in Altitude Deviations / Level Busts

Altitude deviations often occur as the result of one or a combination of the following conditions, that may involve :

- The flight crew,
- The air traffic controller, or,
- The design of the airspace and terminal area procedures.

Flight Crew

Table 2, below, summarizes and ranks the main Flight Management / Flight Monitoring factors observed in altitude deviations / level bust events.

Flight Management / Monitoring Factors	% of Events
Flight Crew Incorrect Selection (Altimeter Setting or Selected Altitude / FL)	25 - 30
Use / Supervision of Automation	10 - 15
Manual Flying / Flight Path Monitoring	10 – 15
Weather (Windshear, Turbulence, Standing Waves)	5 - 10
Adherence to SOPs / Use of Checklists	5 - 10
Response to TCAS / ACAS TA or RA	5 - 10
ATC Service Standard	5

(Source – UK CAA / Eurocontrol / IATA STEADES – 1997-2004)

Table 2

Flight Management / Monitoring Factors in Altitude Deviations / Level Busts

The following detailed contributing factors are often cited in altitude deviations / level bust attributed to flight management / flight monitoring by flight crew :

- Unfamiliar airspace and procedures;
- Callsign confusion (refer to **Flight Operations Briefing Note** on **Effective Pilot / Controller Communications**);

- Late selection of altimeter setting (i.e., STD or QNH / QFE);
- Use of an incorrect altimeter setting (i.e., either incorrectly transmitted by ATC or copied by flight crew), this factor is observed in 10 % of events :
  - Refer to the **Flight Operations Briefing Note** on **Altimeter Setting – Use of Radio Altimeter**;
- Interruption or distraction (refer to the **Flight Operations Briefing Note** on **Managing Interruptions and Distractions**);
- Misunderstanding of the assigned altitude;
- Pilot understands and reads back the correct altitude or FL, but select an incorrect altitude or FL on the FCU, e.g. because of :
  - Confusion of numbers with an other element of the controller's message (e.g., speed, heading or flight number);
  - Expectation / anticipation of another altitude or FL;
  - Interruption / distraction; or,
  - Breakdown in crew crosscheck and backup;
- Pilot / controller communication breakdown (mainly readback / hearback errors), e.g.:
  - Controller transmits an incorrect altitude, the pilot does not readback and the controller does not challenge the absence of readback;
  - Pilot understands and readback an incorrect altitude but controller does not hear back and does not correct the crew readback;
- Lack of active flight path monitoring, resulting in :
  - Failure to level-off at the assigned altitude; or,
  - Failure to reach or maintain the assigned altitude (or altitude restriction) at the point or time assigned by ATC.
- Pilot or autopilot overshoots / undershoots or fails to capture the selected altitude / FL (e.g., due to high rate of climb or descent) ;
- Unanticipated ATC request for step-climb or step-descent;
- Unwarranted response to a TCAS (ACAS) TA;
- Response to a TCAS (ACAS) RA;
- Severe windshear (i.e., up-draught / down-draught);

- Absence of response to the altitude alert aural and visual warnings, when in hand flying; or,
- Incorrect go-around procedure and maneuver.

Air Traffic Controllers

Table 3, below, summarizes and rank the main ATM / ATC factors observed in altitude deviations / level bust events.

ATM / ATC Factors	% of Events
Late Clearance / Re-clearance	50
Complex / Confusing Instructions	20
Inappropriate Vectoring Instructions	10 - 15
Insufficient Separation	5 - 10
Incorrect Coordination Between ATC's	5 - 10
Response to TCAS / ACAS TA or RA	5 - 10
Miscellaneous	5 - 10

(Source – UK CAA / Eurocontrol / IATA STEADES – 1997-2004)

Table 3

ATM / ATC Factors in Altitude Deviations / Level Busts

The following detailed contributing factors are often cited in altitude deviations / level bust attributed to ATM / ATC instructions / services :

- Callsign confusion (refer to **Flight Operations Briefing Note** on **Effective Pilot / Controller Communications**);

- Interruption or distraction (refer to **Flight Operations Briefing Note** on **Managing Interruptions and Distractions**);
- The controller assigns an incorrect altitude, or reassigns a FL after the aircraft has been cleared to an altitude;
- Controller English proficiency / use of standard phraseology / speed of transmission;
- Late altitude clearance / re-clearance not achievable without overshoot / undershoot;
- ATC instruction for an altitude restriction when being above the transition altitude (i.e., with altimeters set to STD);
- Pilot / controller communication breakdown (mainly readback / hearback errors), e.g.:
  - Controller transmits an incorrect altitude, the pilot does not readback and the controller does not challenge the absence of readback;
  - Pilot understands and readback an incorrect altitude but controller does not hear back and does not correct the crew readback; or,
  - Pilot accepts an altitude clearance intended for another aircraft (confusion of callsigns);
- Complex ATC transmission containing more than two instructions (e.g., on speed, altitude and heading);

Design of Airspace and Terminal Area Procedures

The sharing of experience and the joint cooperation between operators and air traffic control services has enabled the initiation of significant enhancements in terms of air traffic management and air traffic control, e.g. :

- Vertical and lateral segregation / deconflicting of arrival and departure procedures to prevent the likelihood of level busts / reduced separations, particularly at sectors' boundaries; and.
- Design of ATC sectors to minimize the need for step-climb or step-descents.

V Prevention Strategies - Altitude Awareness Program

The development and implementation of altitude awareness programs by several airlines have reduced significantly the number of altitude deviations.

To address the main causes of altitude deviations, an altitude awareness program should first assess the company risk exposure and include the following aspects.

Standard Operating Procedures – Crew Resource Management

An altitude awareness program should enhance the respective roles of the PF and PNF by stressing the importance of :

- Strict adherence to Standard Operating Procedures (SOP's) :
  - Task sharing for normal and non-normal operations;
  - Strict adherence to sterile-cockpit rule; and,
  - Briefing techniques that must be resilient to routine !

    (refer to **Flight Operations Briefing Note** on **Conducting Effective Briefings**).

- Strict adherence to Crew Resource Management (CRM) principles, e.g. :
  - Stating (verbalizing) intentions and actions, when they are different from expectations (e.g., delayed climb or descent, management of altitude or speed restrictions); and,
  - Mutual cross-check and back-up.

Pilot / Controller Communications

Breakdown in the pilot/controller communication loop includes:

- Readback / hearback errors (this risk is greater when one crewmember does not monitor radio communications because of other duties such as listening to the ATIS or being involved in company communications or passenger-address announcements);
- Blocked transmissions; or,
- Confusion of call signs.

The following recommendations (discussed and expanded in the **Flight Operations Briefing Note** on **Effective Pilot / Controller Communications**) can enhance communications and raise the level of situational awareness of pilots and controllers :

- Be aware that readback / hearback errors may involve both the pilot and the controller :
  - The pilot may be interrupted or distracted when listening to a clearance, confuse similar callsigns, forget an element of the instruction or be subject to the bias of expectation when understanding or when reading back the instruction (this bias usually is referred to as wish-hearing);

- The controller may also confuse similar callsigns, be distracted by other radio or landline telephone communications or be affected by blocked transmissions or high workload.

- Use standard phraseology for clear and unambiguous pilot / controller and intra-cockpit communications.

  Standard phraseology is the common basis for pilots and controllers; this common language allows an easier detection and correction of errors.

- Use of an adapted phraseology to increase the controller situational awareness, e.g.:
  - When leaving an altitude, announce:

    Leaving [...] for [...]; or,

    Leaving [...] and climbing / descending to [...];

    The call leaving ... should be performed only when a vertical speed of 500 ft/mn has been established and the altimeter positively shows the departure from the previous altitude or FL;

    This recommendation takes a particular importance when descending in a holding pattern;

  - Use of two separate methods for expressing certain altitudes – one one thousand feet, that is eleven thousand feet; and,
  - Preceding each number by the corresponding flight parameter (i.e., FL, heading, speed), e.g., descend to **Flight Level** two four zero instead of descend to two four zero.

- If doubt exists about a clearance, request confirmation from ATC, do not attempt to guess an instruction or clearance based on flight deck discussion.

Task Prioritization and Task Sharing

The following guidelines and recommendations should be considered for optimum prioritization of tasks and task sharing:

- Reduce non-essential tasks during climb and descent (in addition to the sterile cockpit rule, some operators consider the last 1000 ft before reaching any assigned altitude as a sterile-cockpit period);
- Monitor / supervise the operation of AP for correct level-off at the cleared altitude / FL and for correct compliance with altitude or time restrictions (constraints);
- Plan tasks that prevent attentive listening to radio communications (such as copying the ATIS, company calls, and passengers-address announcements) during periods of lesser ATC communications.

- When one crewmember cannot monitor the ATC frequency because of other duties or because leaving the cockpit, the other crewmember should :
  - Acknowledge receiving the radio and controls, as applicable;
  - Check the radio volume to ensure adequate reception of ATC calls;
  - Give an increased attention to listening / confirming / reading back (because of the momentary absence of backup); and,
  - Brief the other crew member when he/she returns, highlighting any relevant new information and any change in the ATC clearance or instructions.

Altitude-setting Procedures

The following techniques should be considered for enhancing standard operating procedures (SOPs):

- When receiving an altitude clearance, set the cleared altitude value immediately in the selected altitude window (even before readback, if deemed more suitable due to workload);
- Ensure that the altitude selected is cross-checked by both crewmembers (e.g., each crew member should verbalize what he or she heard and then point to the selected altitude window to confirm that the correct value has been set);
- Ensure that the cleared altitude is above the sector minimum safe altitude; and,
- When under radar vectoring, be aware of the applicable minimum vectoring altitude for the sector or positively request confirmation of an altitude clearance that is below the sector MSA.

Standard Calls - Callouts

Use standard calls to increase the PF / PNF situational awareness, to ensure an effective backup and challenge, and detect a previous error on the assigned / cleared altitude or FL :

- Modes changes on FMA and changes of targets on PFD/ND;
- Leaving [...] for [...], when a 500 ft/mn vertical speed has been established; and altimeter indicates departure from the previous altitude; and,
- One thousand below (above) [altitude or FL], when within 1000 ft from the cleared altitude or FL.

Note

Although the Airbus SOP's recommend the use of the above standard call, some operators use different standard calls such as :

- *One to go*;
- *One thousand to go*; *or*,
- *[…] for […]*.

When within 1000 ft from the cleared altitude / FL or from an altitude restriction (constraint):

- PF should concentrate on instruments scanning (one head in); and,
- PNF should watch outside for traffic, if in VMC (one head out).

Use of Automation

The use of automation with the correct level of automation for the task and circumstances will assist flight crew in preventing altitude deviations / flight level bust, in conditions such as :

- Unfamiliar airspace / airport;
- Congested airspace;
- Adverse weather; and / or,
- Flight crew experience (e.g., flight crew including a junior first officer).

Refer to the **Flight Operations Briefing Note** on **Optimum Use of Automation** .

VI Flight Level or Altitude Confusion

Confusion between FL 100 and FL 110 (or between 10 000 ft / 11 000 ft) is usually the result of the combination of two or more of the following factors:

- Readback / hearback error because of similar sounding phrases;
- Non adherence to standard ICAO phraseology;
- Mindset leaning to focus only on "one zero" and thus to more easily understand "10 000 feet";

- Failing to question the unusual (e.g. bias of expectation or routine on a familiar SID or STAR) and/or,
- Interpreting subconsciously a request to slow down to 250 kt as a clearance to descend to FL 100.

VII Transition Altitude / Level

As indicated in the **Flight Operations Briefing Note** on **Altimeter Setting – Use of radio Altimeter**, the transition altitude / flight level can be either:

- Fixed for the whole country (e.g. 18 000 ft / FL 180 in the United States); or,
- Transition altitude is defined in the approach charts (e.g., 5000 ft) and transition level is variable as a function of the QNH (as indicated in the ATIS message).

Depending on the airline's / flight crew's usual area of operation, changing from fixed transition altitudes/FL to variable transition altitudes / FL may result in crew confusion and in a premature or late change of the altimeter setting.

In countries operating with reference to the QFE, when below the transition altitude or FL, the readback should indicate the altimeter reference (i.e., QFE).

VIII Altitude Deviations in Holding Patterns

In holding patterns controllers rely on pilots to maintain the assigned altitude or to descend to the new cleared altitude.

The overlay of aircraft tags on the controller's radar display does not allow the immediate detection of an impending traffic conflict.

Controllers, therefore, assume that a correctly readback clearance will be correctly complied with.

Secondary surveillance radar's (SSR) provide conflict alerts but no resolution advisory; accurate and clear pilot / controller communications are essential when descending in a holding pattern.

Two separate holding patterns may be controlled by the same controller, on the same frequency.

The following communication rules are, therefore, important when in a holding pattern:

- Do not take a communication intended for an other aircraft (by confusion of similar callsigns);
- Prevent / minimize the risk of blocked transmission, in case of simultaneous readback by two aircraft with similar callsigns or simultaneous transmissions by the pilot and the controller; and,
- Announce leaving [FL or altitude] only when the vertical speed indicator and the altimeter reflect the departure from the previous altitude.

IX Summary of Key Points

An altitude awareness program should be emphasized during transition and recurrent training and during line checks.

Blame-free reporting of altitude deviation events should be encourage to broaden the understanding of causal and circumstantial factors resulting in altitude deviations.

The following safety key points should be promoted:

- Adhere to the pilot / controller readback / hearback process (communication loop);
- Crosscheck and backup each other to ensure that the altitude selected is the cleared altitude received;
- Cross-check that the cleared altitude is above the sector minimum safe altitude (unless crew is aware of the applicable minimum vectoring altitude for the sector);
- Monitor instruments and automation when approaching the cleared altitude or FL; and,
- In VMC, apply the technique one head inside / one head out when reaching the cleared altitude or FL.

Altitude deviations can be prevented by strict adherence to adequate SOPs, this includes correctly :

- Setting the altimeter-reference on barometric altimeters; and,
- Selecting the cleared altitude or FL on the FCU.

The TCAS (ACAS) is an effective safeguard to minimize the consequences of altitude deviations.

X Associated Flight Operations Briefing Notes

The following **Flight Operations Briefing Notes** refer to altimeter setting and altitude issues, and associated procedures :

- **Operating Philosophy – SOPs**
- **Optimum Use of Automation**
- **Operations Golden Rules**
- **Standard Calls**
- **Effective Pilot / Controller Communications**
- **Managing Interruptions and Distractions**
- **Altimeter Setting – Use of Radio Altimeter**

XI Regulatory references

- **ICAO** :
  - Annex 6, Parts I, II and III, Sections II and III (amended in 1995) for discouraging the use of three-pointer and drum-pointer altimeters
  - Annex 6, Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes, 4.2.6, 6.9.1 c) and Appendix 2, 5.13, 5.15
  - Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-RAC, Doc 4444)
  - Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS, Doc 8168), Volume I, Flight Procedures (Post Amendment No 11, applicable 1 November 2001)

- **US FARs** :
  - FAR 91.119 - Minimum Safe Altitude
  - FAR 91.121 - Altimeter Setting
  - FAR 91.129 - ATC communications
  - FAR 91.221 and FAR 121.356 for TCAS installation
  - FAR 91 – Appendix G – Operations in Reduced Vertical Separation Minima (RVSM) airspace

- **UK CAA** :
  - CAP 413 - Required criteria in announcing leaving an altitude or FL
  - CAP 710 – Level Bust Working Group – " On The Level " project – Final Report – 1999
  - Data $^{+}$ Plus Safety Letter – Level Busts – July 1998
  - Level Bust - website - **http://www.caa.co.uk/srg/levelbust**

XII Industry References

- **Flight Safety Foundation** website – **http://www.flightsafety.org**
  - Flight Safety Digest – June 1993 – Research Identifies Common Errors Behind Altitude Deviations
  - Flight Safety Digest – December 1995 – Altitude Awareness Programs Can Reduce Altitude Deviations
  - Flight Safety Digest – March 1999 – Enhancing Flight Crew Monitoring Skills

- **Eurocontrol** website - **http://www.eurocontrol.int/safety/** :
  - Level Bust Tool Kit – website :
    - **http://www.eurocontrol.int/safety/LevelBust_LevelBust.htm**
  - Level Bust Safety Letters / Bulletins (available on the above Eurocontrol website):
    - Level Bust – A Shared Issue ? – June 2001
    - **Reducing Level Bust – November 2002**
    - En Route to Reducing Level Bust – May 2003
  - ACAS II – website – **http://www.eurocontrol.int/acas/** :
    - Safety Letters and Bulletins
- **NASA** – ASRS website - **http://asrs.arc.nasa.gov/main.htm**
  - *ASRS Directline* bulletin – Issue No.2 – Oct.1991 – International Altimetry
  - *ASRS Directline* bulletin – Issue No.9 – Mar.1997 – The Low-Down on Altimeter Settings
- **IATA** – STEADES - Safety Trend Analysis Report – 2002 and 2004

Airbus Customer Services
Flight Operations Support and Services

1 Rond Point Maurice Bellonte - 31707 BLAGNAC CEDEX FRANCE

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