European Air
Traffic Management

European Action plan for the Prevention of Level Bust

European Organisation for the Safety of Air Navigation

Level Bust

European Action Plan for the Prevention of Level Bust

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1. Statement of Commitment

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The European air transport industry has made considerable progress in driving down accident rates over the past 3 decades and we can be justifiably proud that air travel is the safest method of public transport in Europe. Nevertheless, the number of flights in Europe is forecast to grow by a factor of 2 by 2020, which means that the accident rate must be halved to ensure that the absolute number of accidents does not increase. The safety objective of the ECAC ATM Strategy for 2000+ is “to improve safety levels by ensuring that the number of ATM induced accidents and serious, or risk bearing, incidents do not increase and, where possible decrease”.

The level bust issue is one that has been a concern to the aviation industry for over 10 years now. The deviation of an aircraft from its assigned flight level, for whatever reason clearly jeopardises safety. The developing safety culture within the European air transport industry, and increasing numbers of incident reports generated by pilots and controllers, has helped to raise awareness of this issue. Research by NASA, the FAA, the Flight Safety Foundation, and latterly the UK CAA, has helped to improve our understanding of the causes of level busts, and actions needed to reduce them. While technological developments, such as ACAS and STCA, have helped to reduce the risks associated with a level bust, the absolute number of reported level bust incidents has not declined significantly.

Whilst the majority of level bust incidents do not involve any loss of separation, it is not difficult to imagine the catastrophic outcome and significant loss of life should a mid-air collision occur due to such an occurrence. Indeed, the tragic midair collision that occurred in 1996 near New Delhi and claimed 349 lives was the result of a level bust by one of the aircraft involved. The immediate cause of the accident has been documented as poor flight deck communication and lack of co-ordination, but there were a number of additional contributory factors.

This action plan specifically addresses the subject of level bust prevention and is the result of the combined efforts of organisations representing all areas of airline operations. Those organisations that contributed to this action plan are totally committed to enhancing flight safety by advocating the implementation of the recommendations that it contains.

The recommendations, when implemented, will assist in reducing the number of level bust incidents by the consistent and harmonized application of existing ICAO provisions, improving controller/pilot communications and reporting systems; increasing awareness of the impact of airspace/procedural design processes and by the subsequent increase in situational awareness.

2. Introduction and Background

A Level Bust is defined as "Any deviation from an assigned level in excess of 300 feet" [1]. Within RVSM airspace, this limit is reduced to 200 feet and statistics suggest that 35% of reports to organisational Safety Reporting Systems are level bust related. A number of national CAA organisations have made addressing the level bust issue a priority, however this is not the case in all aviation organisations across the ECAC community and the issue is one of growing concern throughout the industry.

EUROCONTROL began raising awareness of the Level Bust issue in 2001, and commenced its current initiative in 2002 with the publication of a Safety Letter on the subject and two Level Bust Workshops held in Brussels and Palma de Majorca.

EUROCONTROL was determined to act quickly and established a cross-industry task force to formulate an action plan to reduce level busts. The Level Bust Task Force (LBTF) worked within the existing structure of the EUROCONTROL Safety Improvements Sub Group (SISG) and included representatives from ANSPs, airlines, and European institutions. The LBTF aimed to develop the action plan and a Level Bust Toolkit for publication in 2004.

The LBTF made several observations:

Understanding of the number of level busts throughout Europe is limited because of lack of data. We must make greater efforts to improve the level of safety reporting in Europe so that we can identify and understand more clearly the key safety issues.

Several factors have been identified as causing level busts. These include non-adherence to SOPs, terminal chart design, design of instrument flight procedures (SIDs & STARs), RT phraseology and discipline, and callsign confusion. Most level bust events are caused by several of these factors acting together and human factors (human performance limitations) have an effect on all aspects of system and procedure.

Better cooperation between ATC and operators is essential if any progress is to be made in reducing level busts.

UK NATS data indicates that the number of level bust incidents involving military aircraft appears to be proportionately greater than those involving civilian aircraft – this deserves closer examination.

There are variations in the incidence of level busts between airlines. This is encouraging because it shows that much can be done to reduce level busts by adopting best practices (SOPs, reinforced training) that reduce the chances of a level bust.

Recognition is given to those organisations that have already completed a lot of this work.

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[1] EUROCONTROL Harmonisation of European Incident Definitions Initiative (HEIDI)

3. Explanatory Note – Recommendations

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The recommendations are contained in Section 4. For clarity the recommendations have been divided into specific areas for action. It is essential that each organisation take an overview of all recommendations to optimise their own contribution. Guidance on implementing these recommendations, and associated reference material, is contained in the Level Bust Toolkit.

Whereas the National Aviation Safety Authorities have overall responsibility for safety regulation and oversight, the importance of this issue requires that implementation commences at the earliest opportunity by all parties involved. All parties include, but are not limited to, ANSPs, Aircraft Operators, and National Aviation Safety Authorities.

The recommendations are mainly generic and it will be for the responsible organisations to decide specific details, after taking local circumstances into account.

For many of the recommendations contained in this action plan it is suggested that a single representative body take the lead, with other organisations providing support to fully co-ordinate actions. All recommendations suggest a completion date. Progress will be monitored by the LBTF under the auspices of the EUROCONTROL SISG. The urgency of the need to prevent further level bust incidents dictates the high priority of much of the work. Implementation of the recommendations should commence upon receipt of this action plan.

Guidance on implementing these recommendations is contained in the Appendices – Level Bust Briefing Notes. The 14 Briefing Notes are divided into 3 groups – General (GEN), Aircraft Operators (OPS), and Air Navigation Service Providers (ATM).

4. Recommendations

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4.1 Strategic ATM Issues

#	RECOMMENDATION	ACTION	TIMESCALE	BRIEFING NOTE
4.1.1.	Review Airspace Procedure & Design to reduce the likelihood and the severity of level bust incidents	**Primary:** National Authorities **Supporting :** EUROCONTROL Agency	1 July 2005	ATM 4

4.2 Air Traffic Control (ATC) Issues

#	RECOMMENDATION	ACTION	TIMESCALE	BRIEFING NOTE
4.2.1	Improve the level of safety reporting	**Primary:** National Authorities **Supporting :** EUROCONTROL Agency, ANSPs	SSAP IMP*	ATM 3
4.2.2	Improve co-operation between ATC and Aircraft Operators in the investigation of level bust incidents	**Primary:** National Authorities **Supporting :** EUROCONTROL Agency, ANSPs, Aircraft Operators	1 July 2005	ATM 3, OPS 7
4.2.3	Review ATC Operating Procedures (SOPs) & Training to reduce the liklihood the severity of level bust incidents	**Primary:** ANSPs **Supporting :** EUROCONTROL Agency, National Authorities	1 July 2005	ATM 1 ATM 2
4.2.4	Ensure that level bust issues are included in training and briefing for ATC staff	**Primary:** ANSPs **Supporting :** EUROCONTROL Agency, National Authorities	1 July 2005	ATM 1 ATM 2
4.2.5	Introduce Team Resource management (TRM) training.	**Primary:** ANSPs **Supporting :** EUROCONTROL Agency, National Authorities	1 July 2005	ATM 1 ATM 2
4.2.6	Radio Discipline: Use standard ICAO phraseology	**Primary:** National Authorities **Supporting :** EUROCONTROL Agency, ANSPs	Immediate	GEN 2
4.2.7	Radio Discipline: Avoid giving mulitiple clearances in the same transmission.	**Primary:** National Authorities **Supporting :** EUROCONTROL Agency, ANSPs	Immediate	ATM 1
4.2.8	Radio Phraseology: Review and, if required, propose changes to ICAO standard phraseology to reduce the risk of a level bust.	**Primary:** EUROCONTROL Agency **Supporting :** ANSPs, IATA	Not applicable	Not applicable

* Strategic Safety Action Plan Implementation Master Plan

4.3 Aircraft Operator Issues

#	RECOMMENDATION	ACTION	TIMESCALE	BRIEFING NOTE
4.3.1	Review SOPs to reduce the liklihood of level busts	**Primary:** Aircraft Operators **Supporting :** IATA, National Authorities	Immediate	OPS 1
4.3.2	Reduce flight deck workload by avoiding all activity not directly related to the safe conduct of the flight	**Primary:** Aircraft Operators **Supporting :** IATA, National Authorities	Immediate	OPS 1
4.3.3	Ensure clear procedures for altimeter cross-checking and approaching level calls	**Primary:** Aircraft Operators **Supporting :** IATA, National Authorities	Immediate	OPS 2
4.3.4	Always confirm the clearance if any doubt exists on the flight deck	**Primary:** Aircraft Operators **Supporting :** IATA, National Authorities	Immediate	GEN 2 OPS 3
4.3.5	Always report the level cleared to when checking in on a new frequency while in the climb or descent	**Primary:** Aircraft Operators **Supporting :** IATA, National Authorities	Immediate	GEN 2 OPS 3

4.4 Future Considerations *(issues currently beyond the immediate scope of the level bust action plan but which deserve further examination and evaluation)*

#	RECOMMENDATION	ACTION	TIMESCALE
4.4.1	Consider introduction of Mode "S"/Datalink to provide controllers with information on subscale setting and selected altitude	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable
4.4.2	Consider establishment of common european transition altitude	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable
4.4.3	Consider harmonisation of chart design	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable
4.4.4	Highlight local safety issues	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable
4.4.5	Establish standard for the maximum amount of data on a plate	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable
4.4.6	Increase understanding of the role of human factors in level busts.	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable
4.4.7	Consider formal human factors audits of procedures and design	**Primary:** EUROCONTROL Agency **Supporting :** National Authorities	Not applicable

5. Follow-up Actions

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Some of the actions contained in this plan are already underway as a result of complementary safety initiatives whilst others are specific to the level bust issue. When the action plan has been agreed, an implementation monitoring function will be established. Progress of all the actions, new data on level busts, and further study into the causes of level busts will be monitored and all stakeholders will be advised of progress.

The Action Plan for the Prevention of Level Busts will be updated to reflect any changes that become necessary. It is intended that the second edition of this document will start to look at some of the longer-term issues, such as chart design and human factors.

5.1 Communication

The Action Plan will be distributed in hard copy to national authorities, ANSPs, and aircraft operators and be made available on-line via the EUROCONTROL website. Publication of the Action Plan will be a precursor to circulation of the Level Bust Toolkit. The target date of publication is July 2004.

5.2 Monitoring

The Level Bust Task Force, reporting to the EUROCONTROL Safety Improvement Sub Group (SISG), will act as the monitoring group for the Action Plan. It's function will be to:

- Monitor the level bust risk - gather data on level busts from airlines, service providers, and authorities
- Monitor implementation of the action plan by "Actors" (National authorities etc.)
- Monitor distribution, use, and effectiveness of the toolkit.

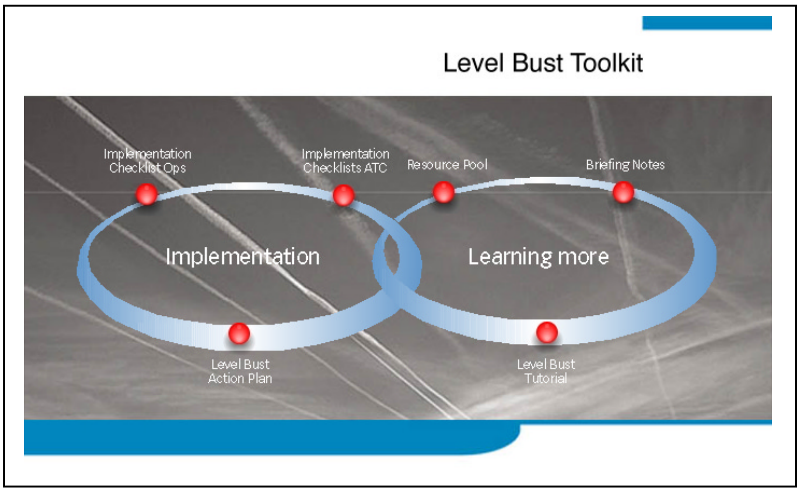
6. The Level Bust Toolkit

The Level Bust Toolkit is designed to help safety managers implement the action plan and develop their own strategies to raise awareness of the level bust issue and reduce level busts. It also serves as a learning resource for anyone interested in learning more about the level bust issue.

On loading the CD, the user enters an entrance portal where a Flash presentation introduces the level bust issue and briefly explains how to use the toolkit.

The user can skip through to the Introduction menu…

…and then choose to either view the Level Bust Action Plan, to work through a step by step guide to reducing level busts and implementing the Action Plan, specially designed for safety managers of aircraft operators and air navigation service providers (**Implementation**), …



…or to freely explore the Toolkit resources, briefing notes, and Level Bust Tutorial (**Learning More**).

Central to the toolkit are detailed briefing notes linked to source references. The Resource Pool contains material which the can be used to increase understanding of the level bust issue within organisations.

Appendices – Level Bust Briefing Notes

Appendices

Gen 1: Level Busts - Overview
Gen 2: Pilot-Controller Communications
Gen 3: Call Sign Confusion
Ops 1: Standard Operating Procedures
Ops 2: Altimeter Setting Procedures
Ops 3: Standard Calls
Ops 4: Aircraft Technical Equipment
Ops 5: ACAS
Ops 6: Human Factors
Ops 7: Safety Reporting - Operators
ATM 1: Understanding the Causes of Level Busts
ATM 2: Reducing Level Busts
ATM 3: Safety Reporting - ATM
ATM 4: Airspace & Procedure Design

GEN 1
Level Bust: Overview

1. Introduction

1.1. EUROCONTROL has become increasingly aware of the Level Bust issue. In 2001 EUROCONTROL issued a series of Safety Letters[1] within the industry to raise the awareness of aircraft operators and air navigation service providers (ANSPs) to the dangers associated with level busts, and to provide guidance on the correct use of airborne collision avoidance systems (ACAS).

1.2. In 2002, a Level Bust Task Force (LBTF) was established and EUROCONTROL held two Level Bust Workshops, the first in Northern Europe; the second in the South. These workshops attracted delegates from all sectors of the airline industry. Various parties who have studied the issue made presentations[2] and there was valuable discussion, including an exchange of ideas as to the best way forward.

1.3. Following the second workshop the LBTF made a number of *recommendations*[3] aimed at addressing and reducing the level bust threat.

1.4. It was decided that a Level Bust Toolkit should be developed to assist aircraft operators and ANSPs to incorporate best practice in their operational procedures. The Level Bust Toolkit includes all the recommendations of the LBTF.

1.5. Level Busts or Altitude Deviations, are a potentially serious aviation hazard and occur when an aircraft fails to fly at the level required for safe separation. When reduced vertical separation minima (RVSM) apply, the potential for a dangerous situation to arise is increased.

1.6. This operational hazard may result in serious harm, either from a mid-air collision or from collision with the ground (controlled flight into terrain [CFIT]). Occasionally, a rapid avoidance manoeuvre may be necessary, which may result in injuries to passengers, flight crewmembers, and particularly to cabin crewmembers.

1.7. This Briefing Note provides an overview of the factors involved in level busts.

2. Statistical Data

2.1. An analysis of level busts[4] by the US Federal Aviation Administration (FAA) and by USAir (now US Airways) showed that:

(a) Approximately 70% of level busts were the result of a breakdown in pilot-controller communications; and,

(b) Nearly 40% of level busts resulted when air traffic control (ATC) assigned 10,000 feet and the flight crew set 11,000 feet in the selected altitude window, or vice-versa.

2.2. The "*On the Level*"[5] project conducted by the UK CAA during 1999 found that of 626 level bust incidents reported, the top six causal factors, amounting to more than 70% of all incidents, were

(a) Operation in SIDs;

(b) Autopilot problems;

(c) Failure to follow ATC instructions;

(d) Altimeter mis-setting;

(e) Pilot handling; and,

(f) Confusion over cleared level.

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[1] EUROCONTROL Safety Letters. See Training Material (Page 6) and http://www.eurocontrol.int/safety/SafetyLetters.htm
[2] Proceedings of the second level bust workshop. See http://www.eurocontrol.int/safety/LevelBust_LevelBust.htm
[3] See Level Bust Action Plan
[4] Flight Safety Foundation (FSF) Digest 6/93 – Research Identifies Common Errors behind Altitude Deviation
[5] UK CAA: CAP 710 – "On the Level" and associated recommendations

3. Defining a Level Bust

3.1. The EUROCONTROL (HEIDI[6]) definition of a level bust is:

Any unauthorised vertical deviation of more than 300 feet from an ATC flight clearance.

3.2. The definitions of other authorities refer to a deviation equal to or greater than 300 feet.

3.3. Within RVSM airspace this limit is reduced to 200 feet.

3.4. These briefing notes address solely the level bust issue as defined by EUROCONTROL. Actual or potential loss of separation resulting from controller error will not be considered.

4. Causes of Level Busts

4.1. Level busts are usually the result of a breakdown in either:

(a) The pilot-equipment interface (altimeter setting, use of autopilot, monitoring of instruments and displays); or,

(b) The pilot-controller interface (the confirmation/correction process).

4.2. Level busts usually occur as the result of one or more of the following conditions:

(a) Controller-induced situations, such as the following:

– Late reclearance;

– The controller assigns an *altitude* after the pilot was cleared to a *flight level* (climbing);

– The controller assigns a *flight level* after the pilot was cleared to an *altitude* (descending).

(b) Pilot-controller communication breakdown – mainly readback/hearback errors such as the following:

– Pilot mishears level clearance, the pilot does not read back the level and the controller does not challenge the absence of readback;

– Pilot reads back an incorrect level but controller does not hear the erroneous readback and does not correct the pilot's readback; or,

– Pilot accepts a level clearance intended for another aircraft (confusion of callsigns).

(c) Pilot understands and reads back the correct altitude or flight level, but select an incorrect altitude or flight level because of:

– Confusion of numbers with another element of the message (e.g. speed, heading or flight number);

– Expectation of another altitude or flight level;

– Interruption/distraction; or,

– Breakdown in crew cross-checking;

(d) Autopilot fails to capture the selected altitude;

(e) The crew does not respond to the altitude-alert aural and visual warnings when hand flying; or,

(f) The crew conducts an incorrect go-around procedure.

5. Altitude Awareness Programme

5.1. The development and implementation of altitude awareness programmes by several airlines has significantly reduced the number of level busts.

5.2. To address the main causes of level busts, an altitude awareness programme should include the following aspects.

General

5.3. An altitude awareness programme should enhance the monitoring roles of the pilot flying (PF) and the pilot not flying (PNF) (pilot monitoring) by emphasising the importance of:

(a) Communicating intentions and actions, particularly when they are different from expectations (e.g. delayed climb or descent, management of altitude or speed restrictions); and,

(b) Cross-checking and actively monitoring.

Communications

5.4. The FAA-USAir study[4] showed that approximately 70 percent of level busts are the result of breakdown in the pilot-controller communication loop caused by:

(a) Readback/hearback errors (this risk is greater when one pilot does not monitor radio communications because of other duties such as listening to the automated terminal

[6] HEIDI – Harmonisation of European Incident Definitions for ATM.

information service (ATIS), complying with company communications requirements or making public-address announcements);

(b) Blocked transmissions; or,

(c) Confusion of callsigns.

5.5. The following recommendations improve communications and situational awareness:

(a) Be aware that readback/hearback errors involve both the pilot and the controller;

– The pilot may be interrupted or distracted when listening to a clearance, be subject to forgetfulness or be subject to the bias of expectation when listening to or reading back the instruction (this bias is also termed *wish-hearing*) or may be confused by similar callsigns; and,

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

(b) Use standard phraseology for clear and unambiguous pilot-controller communications and crew communication:

– Standard phraseology is a common language for pilots and controllers, and this common language increases the likelihood of detecting and correcting errors.

(c) Use expanded phraseology such as:

– Announcing when leaving a flight level or altitude (e.g. “leaving […] for […],” or, “leaving […] and climbing/descending to […]”), thus increasing the controller’s situational awareness;

– Combining different expressions of specific altitudes (e.g. “one one thousand feet – that is eleven thousand feet”); and,

– Preceding each number by the corresponding flight parameter (flight level, heading, airspeed [e.g. “descend to flight level two four zero” instead of “descend to two four zero”]).

(d) When in doubt about a clearance, request confirmation from the controller; do not guess about the clearance based on crew discussion.

Task prioritisation and task sharing

5.6. The following recommendations should enable optimum prioritisation of tasks and task sharing:

(a) Stop nonessential tasks during critical phases of flight.

– In the USA, a “*Sterile Cockpit*”[7] rule has been established which defines critical stages of flight and what activities are permitted during them. Many European operators enforce similar procedures by their crews.

– Some operators consider the final 1,000 feet before reaching the cleared altitude or flight level as a critical stage of flight;

(b) Monitor/supervise the operation of autopilot/FMS to confirm correct level-off at the cleared altitude and for correct compliance with altitude or time restrictions;

(c) Plan tasks that preclude listening to ATC communications (e.g. ATIS, company calls, public-address announcements) for periods of infrequent ATC communication; and,

(d) When one pilot does not monitor the ATC frequency while doing other duties (e.g. company calls) or when leaving the flight deck, the other pilot should:

– Acknowledge that he/she has responsibility for ATC radio communication and aircraft control, as applicable;

– Check that the radio volume is adequate to hear an ATC call;

– Give increased attention to listening/ confirming/reading back (because of the absence of cross-checking); and,

– Brief the other pilot when he/she returns, highlighting any relevant new information and any change in ATC clearance or instructions.

Altitude-setting procedures

5.7. The following techniques enhance standard operating procedures (SOPs):

(a) When receiving a level clearance, immediately set the cleared altitude in the selected altitude window;

(b) Ensure that the selected level is cross-checked by both pilots (e.g. each pilot should announce what he/she heard and then point to the selected altitude window to confirm that the correct value has been set);

[7] FSF Digest 7/94 – Accident and Incident Reports Show Importance of Sterile Cockpit Compliance.

(c) Ensure that the cleared level is above the minimum safe altitude (MSA); and,

(d) Positively confirm the level clearance when receiving radar vectors.

Callouts

5.8. Use the following calls to increase PF/PNF situational awareness and to ensure effective backup and challenge, (and to detect a previous error in the cleared altitude or flight level):

(a) Mode changes on the flight mode annunciator (FMA) and changes of targets (e.g. airspeed, heading, altitude) on the primary flight display (PFD) and navigation display (ND);

(b) "Leaving [...] for […]" and,

(c) "One to go", "One thousand to go", or "[…] for […]" when within 1000 feet of the cleared altitude or flight level.

5.9. When within 1000 feet of the cleared altitude or flight level or an altitude restriction in visual meteorological conditions (VMC), one pilot should concentrate on scanning instruments (one head down) and one pilot should concentrate on traffic watch (one head up).

6. Flight Level or Altitude Confusion

6.1. Confusion between FL 100 and FL 110 (or between 10,000 feet and 11,000 feet)[8] is usually the result of the combination of two or more of the following factors:

(a) Readback/hearback error because of similar sounding phrases;

(b) Phraseology used, e.g.:

– ICAO standard phraseology is "flight level one zero zero" and "flight level one one zero";

– The non-standard phraseology: "flight level one hundred" is used by a number of European air navigation service providers (ANSPs);

(c) Mindset tending to focus only on "one zero" and thus to understand more easily "flight level one zero zero";

(d) Failing to question the unusual (e.g. bias of expectation on a familiar standard terminal arrival [STAR]); and/or,

(e) Subconsciously interpreting a request to slow down to 250 kt as a clearance to descend to FL 100 (or 10,000 feet).

7. Transition Altitude/Level

7.1. The transition altitude is the altitude at or below which the vertical position of an aircraft is controlled by reference to altitude[9]. The transition level is a variable level above the transition altitude, above which the vertical position of the aircraft is determined by reference to flight level. The transition level varies according to the local atmospheric pressure and temperature.

7.2. The transition altitude may be either:

(a) Fixed for the whole country (e.g. 18,000 feet in the United States);or,

(b) Fixed for a given airport (as indicated on the approach chart);

7.3. Depending on the airline's or flight crew's usual area of operation, changing from fixed transition altitude to variable transition level may result in a premature resetting or a late resetting of the altimeter.

7.4. An altitude restriction (expressed in altitude or flight level) may also advance or delay the change of the standard altimeter setting (1013.2 hPa or 29.92 in. Hg) possibly resulting in crew confusion.

7.5. In countries operating with QFE, the readback should indicate the altimeter reference (i.e. QFE).

8. High Rates of Climb and Descent

8.1. High rates of climb and descent increase the likelihood of a level bust and reduce the opportunity for correcting error before a dangerous situation arises. High rates of climb or descent may also trigger ACAS nuisance warnings.

8.2. In any airspace ATC may impose minimum and maximum rates of climb and descent; this is particularly true within RVSM airspace during the last 1,000 feet of climb or descent to cleared flight level.

8.3. Whether or not a restriction applies, it is good practice to reduce the rate of climb or descent to below 1,500 feet/min when within 1,000 feet of the cleared flight level.

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[8] Transition altitudes as high as 10,000 feet are uncommon in Europe but are regularly found elsewhere, (e.g. in most parts of North America the Transition Altitude is 18,000 feet).

[9] ICAO Annex 2 Chapter 1.

9. Level Busts in Holding Patterns

9.1. Controllers assume that pilots will adhere to a clearance that the pilot has read back correctly.

9.2. Two separate holding patterns may be under the control of the same controller on the same frequency.

9.3. With aircraft in holding patterns, controllers place particular reliance on pilots because the overlay of aircraft data labels on the controller's radar display may not allow the immediate detection of an impending traffic conflict.

9.4. Accurate pilot-controller communication is essential when descending in a holding pattern because of the reduced effectiveness of the usual safety-net of short term conflict alert (STCA) and (ACAS):

(a) STCA may in some cases be disabled;

(b) SSR transponders may be required to be switched off; and,

(c) ACAS may be required to be switched to TA-only.

9.5. The following pilot actions are important when in a holding pattern:

(a) Do not take a communication intended for an other aircraft (by confusion of similar callsigns); and,

(b) Prevent or minimise the risk of blocked transmission, (e.g. simultaneous readback by two aircraft with similar callsigns, or simultaneous transmissions by the pilot and the controller);

10. ACAS (TCAS)

10.1. Used correctly, ACAS is an effective tool to help prevent mid-air collisions, which can result from level busts. Operators must develop and enforce SOPs that ensure that pilots respond correctly if the ACAS warning conflicts with instructions from ATC.

11. Summary

11.1. Level busts can be prevented by adhering to SOPs to:

(a) Set the altimeter reference; and,

(b) Select the cleared altitude or flight level.

11.2. To be effective, an altitude awareness programme should be emphasised during transition training, recurrent training and line checks.

11.3. Blame-free reporting of level bust events should be encouraged to broaden knowledge of the causal factors of level busts.

11.4. The following should be promoted:

(a) Adhere to the pilot-controller confirmation/ correction process (communication loop);

(b) Practice flight crew cross-checking to ensure that the *selected* altitude is the *cleared* altitude;

(c) Cross-check that the cleared altitude is above the MSA;

(d) Monitor instruments and automation when reaching the cleared altitude or flight level; and,

(e) In VMC, apply the technique one head down and one head up when reaching the cleared altitude or flight level.

12. Resources

Other Level Bust Briefing Notes

12.1. The Level Bust Toolkit includes fourteen briefing notes arranged in three series.

12.2. The first series consists of three general notes of equal relevance to pilots and controllers alike:

GEN 1 – Level Busts: Overview;

GEN 2 – Pilot-Controller Communications;

GEN 3 – Callsign Confusion.

12.3. The second series is slanted towards the needs of the aircraft operator and pilot:

OPS 1 – Standard Operating Procedures;

OPS 2 – Altimeter Setting Procedures;

OPS 3 – Standard Calls;

OPS 4 – Aircraft Technical Equipment;

OPS 5 – Airborne Collision Avoidance Systems;

OPS 6 – Human Factors;

OPS 7 – Safety Reporting: Operators.

12.4. The third series is of particular importance for air traffic management (ATM) and the controller.

ATM 1 – Understanding the Causes of Level Busts;

ATM 2 – Reducing Level Busts;

ATM 3 – Safety Reporting: ATM;

ATM 4 – Airspace & Procedure Design.

Access to Resources

12.5. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from *ICAO*;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from *FSF*;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from *JAA*.

Regulatory References

12.6. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 2 – Rules of the Air:

3.2: Avoidance of Collisions;

3.6.2: Adherence to Flight Plans;

ICAO Annex 6, Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes:

Paragraph 4.2.6 – minimum flight altitudes;

Appendix 2 – Contents of an Operations Manual Para 5.13 – Instructions on the maintenance of altitude awareness and the use of automated or flight crew altitude call-out;

ICAO Doc 4444 – Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-ATM);

ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I, Flight Procedures.

Training Material – Safety Letters

EUROCONTROL Safety Letter – Level Bust: a Shared Issue?;

EUROCONTROL Safety Letter – Reducing Level Bust;

EUROCONTROL Safety Letter – En Route to Reducing Level Bust.

Training Material – Posters

Level Bust Prevention posters produced by the UK CAA:

2 Many Things;

Low QNH – High Risk;

No Rush – No Mistake;

Wun Wun Zero.

Training Material – Videos

UK NATS Video: Level Best.

Incident Reports

FSF Accident Prevention 12/98 – Aircraft Accidents Aren't Pt 1;

FSF Accident Prevention 1/99 – Aircraft Accidents Aren't Pt 2;

FSF Accident Prevention 4/97 – MD83 Descends Below Minimum Descent Altitude;

NASA ASRS Directline Issue No 10 – Crossing Restriction Altitude Deviations;

NASA Altitude Deviations – Breakdowns in an Error Tolerant System;

NASA ASRS Database Report Set – Altitude Deviations;

UKAAIB – Airbus A330/Airbus A340 over Atlantic.

Other References

EUROCONTROL – Proceedings of the Second Level Bust Workshop;

EUROCONTROL – Recommendations of the Level Bust Task Force;

FSF Approach & Landing Accident Reduction (ALAR) Toolkit Briefing Note 3.2 – Altitude Deviations;

FSF Approach & Landing Accident Reduction (ALAR) Toolkit Briefing Note 1.3 – Operations Golden Rules;

FSF Digest 11/98 – "Killers in Aviation": Facts about Controlled Flight Into Terrain Accidents;

FSF Digest 6/93 – Research Identifies Common Errors behind Altitude Deviation;

FSF Digest 7/94 – Accident and Incident Reports Show Importance of Sterile Cockpit Compliance;

FSF Digest 12/95 – Altitude Awareness Programs Can Reduce Altitude Deviations;

IATA Report: Problems Around the World with English Language in Civil Aviation;

Proceedings of the Royal Aeronautical Society (RAeS) Human Factors Group – Altitude Bust Conference;

UK Airprox Board Report Analysis of Airprox in UK Airspace – July 2001 to December 2001;

UK Airprox Board Report Analysis of Airprox in UK Airspace – January 2002 to June 2002;

UK CAA AIC 107/2000 – Callsign Confusion;

UK CAA CAP 710 – "On the Level" and associated recommendations;

UK CAA – Recommendations Originating from the "On the Level" Project;

UK CAA Flight Operations Department Communication 2/97 – Altitude Violations;

UK NATS – Incidents Around Stacks: A Pilot's View.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

GEN 2
Pilot-Controller Communications

1. Introduction

1.1. Until data link communication comes into widespread use, air traffic control (ATC) will depend primarily upon voice communication.

1.2. Communication between pilot and controller can be improved by the mutual understanding of each other's operating environment.

2. Cross-checking on the Flight Deck

2.1. The first line of defence is the cross-checking process that exists on the flight deck between the pilot flying (PF) and the pilot not flying (PNF) (pilot monitoring).

2.2. The following procedure is typical in many airlines:

(a) When the autopilot is engaged, the PF sets the cleared altitude;

(b) When the autopilot is not engaged, the PNF sets the cleared altitude.

(c) Each altitude setting triggers a cross-check:

(d) The PF calls out the altitude set;

(e) The PNF checks what has been set and announces the value of the altitude.

This procedure allows any discrepancy, in what was heard by the pilots, or in the setting made to be resolved without delay.

2.3. The procedure in use within an airline must be standardised, clearly stated in the operations manual, reinforced during training and adhered to by all pilots.

3. Pilot-Controller Communication Loop

3.1. The responsibilities of the pilot and controller overlap in many areas and provide backup.

3.2. The pilot-controller confirmation/correction process is a "loop" that ensures effective communication (Figure 1).

3.3. Whenever adverse factors are likely to affect communication, the confirmation/correction process is a line of defence against communication errors.

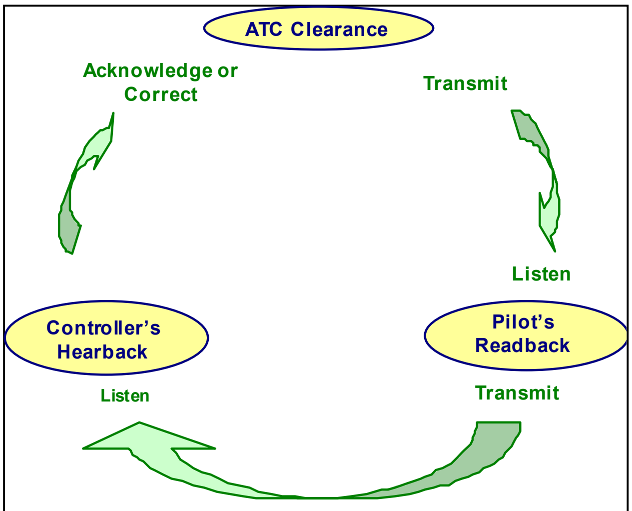

Figure 1
The Pilot / Controller Communication Loop

4. Effective Communications

4.1. Pilots and controllers are involved equally in the air traffic management (ATM) system.

4.2. Achieving effective radio communications involves many factors that should not be considered in isolation; more than one factor is usually involved in a breakdown of the communication loop.

Human Factors

4.3. Effective communication is achieved when the message transmitted by one party is correctly interpreted and understood by the other party.

4.4. This process can be summarised as follows:

(a) How do we *perceive* the message?

(b) How do we *reconstruct* the information contained in the message?

(c) How do we link this information to an *objective* or to an *expectation* (e.g. route, altitude or time)?

(d) What *bias* or *error* is introduced in this process?

4.5. Crew resource management (CRM) (for pilots) and team resource management (TRM) (for controllers) highlight the relevance of the *context* and *expectation* in communication. Nevertheless, expectations may introduce either a positive or a negative bias in the effectiveness of the communication.

4.6. High workload, fatigue, distractions, interruptions and conflicts are among the factors that may adversely affect pilot-controller communications and result in:

(a) Incomplete communication;

(b) Omission of callsign or use of an incorrect callsign;

(c) Use of non-standard phraseology;

(d) Failure to hear or to respond; and,

(e) Failure to implement effectively a confirmation or correction.

Language and Communication

4.7. Native speakers may not speak their own language correctly. The language of pilot-controller communication is intended to overcome this basic shortcoming.

4.8. The first priority of any communication is to establish an *operational context* that defines the following elements:

(a) **Purpose** – clearance, instruction, conditional statement or proposal, question or request, confirmation;

(b) **When** – immediately, anticipate, expect;

(c) **What and how** – altitude (climb, descend, maintain), heading (left, right), airspeed; and,

(d) **Where** – (at […] waypoint).

4.9. The construction of the initial and subsequent message(s) should support this operational context by:

(a) Following the chronological order of the actions;

(b) Grouping instructions and numbers related to each action; and,

(c) Limiting the number of instructions in the transmission.

4.10. The intonation, the speed of speaking and the placement and duration of pauses may affect the understanding of a communication.

Mastering the Language

4.11. CRM studies show that language differences on the flight deck are a greater obstacle to safety than cultural differences.

4.12. Because English has become a shared language in aviation, an effort has been initiated to improve the English-language skills of pilots and controllers world-wide.

4.13. Nevertheless, even pilots and controllers for whom English is the native language may not understand all words spoken in English, because of regional accents or dialects.

4.14. In many regions of the world language differences generate other communication difficulties.

4.15. For example, controllers using both English (for communication with international flights) and the country's official language (for communication with domestic flights) hinder some flight crews from achieving the desired level of situational awareness (loss of "party-line communications").

Non-standard Phraseology

4.16. Non-standard phraseology is a major obstacle to effective communications.

4.17. Standard phraseology in pilot-controller communication is intended to be universally understood.

4.18. Standard phraseology helps lessen the ambiguities of spoken language and thus facilitates a common understanding among speakers:

(a) Of different native languages; or,

(b) Of the same native language, but who use, pronounce or understand words differently.

4.19. Non-standard phraseology or the omission of key words may completely change the meaning of the intended message, resulting in potential traffic conflicts.

4.20. For example, any message containing a number should indicate what the number refers to (e.g. a flight level, a heading or an airspeed). Including key words prevents erroneous interpretation and allows an effective readback/hearback.

4.21. Particular care is necessary when certain levels are referred to because of the high incidence of confusion between, for example, FL100 and FL110.

4.22. Non-standard phraseology is sometimes adopted unilaterally by national or local air traffic services, or is used by pilots or controllers in an attempt to alleviate these problems; however, standard phraseology minimises the potential for misunderstanding. Section 7 lists examples of phraseology which have been adopted for use by UK CAA, but which are contrary to ICAO standard.

Building Situational Awareness

4.23. Radio communications should contribute to the pilot's and the controller's situational awareness, which may be enhanced if they provide each other with advance information.

Frequency Congestion

4.24. Frequency congestion significantly affects the flow of communications, especially during approach and landing phases at high-density airports, and demands enhanced vigilance by pilots and by controllers.

Omission of Callsign

4.25. Omitting the callsign or using an incorrect callsign jeopardises an effective readback/hearback.

Omission of Readback or Inadequate Readback

4.26. The term "roger" is often misused, as in the following situations:

(a) A pilot says "roger" (instead of providing a readback) to acknowledge a message containing numbers, thus preventing effective hearback and correction by the controller; or,

(b) A controller says "roger" to acknowledge a message requiring a definite answer (e.g. a positive confirmation or correction, such as acknowledging a pilot's statement that an altitude or speed restriction cannot be met), thus decreasing both the pilot's and the controller's situational awareness.

Failure of Correct Readback

4.27. The absence of an acknowledgement or a correction following a clearance readback is perceived by most flight crews as an implicit confirmation of the readback.

4.28. The absence of acknowledgement by the controller is usually the result of frequency congestion and the need for the controller to issue clearances to several aircraft in succession.

4.29. An uncorrected erroneous readback (known as a *hearback error*) may lead to a deviation from the cleared altitude or non-compliance with an altitude restriction or with a radar vector.

4.30. A deviation from an intended clearance may not be detected until the controller observes the deviation on his/her radar display.

4.31. Less than required vertical or horizontal separation (and near mid-air collisions) is often the result of hearback errors.

Expectations

4.32. Bias in understanding a communications can affect pilots and controllers.

4.33. The bias of expectation can lead to:

(a) Transposing the numbers contained in a clearance (e.g. a flight level) to what was expected, based on experience or routine; and,

(b) Shifting a clearance or instruction from one parameter to another (e.g. perceiving a clearance to maintain a 280° heading as a clearance to climb/descend and maintain flight level 280).

Failure to Request Confirmation or Clarification

4.34. Misunderstandings may include half-heard words or guessed-at numbers.

4.35. The potential for misunderstanding numbers increases when an ATC clearance contains more than two instructions.

4.36. Reluctance to seek confirmation may cause pilots to:

(a) Accept an inadequate instruction (over-reliance on ATC); or,

(b) Determine for themselves the most probable interpretation.

4.37. Failing to request clarification may cause flight crew to believe erroneously that they have received an expected clearance (e.g. clearance to climb to a requested level).

Failure to Question Instructions

4.38. Failing to question an instruction can cause a crew to accept an altitude clearance below the minimum safe altitude (MSA) or a heading that places the aircraft on collision course with another.

> *If there is any doubt as to the content of a clearance, or its meaning is not clearly understood, pilots must obtain clarification or confirmation.*

Taking Another Aircraft's Clearance or Instruction

4.39. Level busts often occur because an aircraft accidentally takes a clearance intended for another aircraft.

4.40. This usually occurs when two aircraft with similar-sounding callsigns are on the same RTF channel[1] and are likely to receive similar instructions, or the callsign is blocked by another transmission.

4.41. When pilots of different aircraft with similar-sounding callsigns omit the callsign on readback, or when simultaneous readbacks are made by both pilots, the error may go unnoticed by the pilots and the controller.

4.42. Some national authorities have instituted callsign de-confliction programmes.

4.43. All operators should study their schedules and arrange callsigns to reduce the chance of company aircraft operating in the same airspace at the same time having similar callsigns.

Filtering Communications

4.44. Because of other flight deck duties, pilots tend to filter communications, hearing primarily communications that begin with their aircraft callsign and not hearing most other communications.

4.45. For workload reasons, controllers may also filter communications (e.g. not hearing or responding to a pilot readback while engaged in issuing clearances/instructions to other aircraft, or ensuring internal co-ordination).

4.46. To maintain situational awareness, this filtering process should be adapted, according to the flight phase, for more effective listening.

4.47. For example, when operating in congested airspace the pilots should listen and give attention to all communications related to clearances to climb or descend to, or through, their level.

Timeliness of Communications

4.48. Deviating from an ATC clearance may be required for operational reasons (e.g. a heading deviation or altitude deviation for weather avoidance, or an inability to meet a restriction).

4.49. Both the pilot and the controller need time to accommodate this deviation; therefore ATC *should be notified as early as possible* to obtain a timely acknowledgement.

4.50. Similarly, when about to enter a known non-radar-controlled flight information region (FIR), the pilot should contact the appropriate ATC facility approximately 10 minutes before reaching the FIR boundary to help prevent misunderstandings or less-than-required separations.

Blocked or Simultaneous Transmissions

4.51. Blocked transmissions are responsible for many altitude deviations.

4.52. Blocked transmissions are often the result of not immediately releasing the push-to-talk switch after a communication.

4.53. An excessive pause in a message (i.e. holding the push-to-talk switch while preparing the next item of the transmission) may also result in blocking part of the response or part of another message.

4.54. Simultaneous transmission by two stations (two aircraft or one aircraft and ATC) results in one of the two (or both) transmissions being *blocked* and *unheard* by the other stations (or being heard as a buzzing sound or as a squeal).

4.55. The absence of a readback from the pilot should be treated as a blocked transmission and prompt a request to repeat or confirm the message.

4.56. In practice, most pilots are unlikely to treat the absence of a hearback acknowledgement from the controller as evidence of a blocked transmission, and only question the controller if they are uncertain that the read-back was correct or have other reasons to suspect a blocked transmission.

4.57. Although not official procedure, some pilots make a practice of alerting controllers and other pilots to an apparent blocked or garbled transmission by saying "Blocked" immediately afterwards.

[1] Refer to briefing note GEN 3 – Callsign Confusion.

5. Communicating Specific Events

5.1. The following events should be reported as soon as practical to ATC, stating the nature of the event, the actions taken and the flight crew's further intentions:

(a) Airborne collision avoidance system (ACAS) resolution advisory (RA);

(b) Severe turbulence;

(c) Volcanic ash;

(d) Windshear or microburst; and,

(e) A terrain avoidance manoeuvre prompted by a ground proximity warning system (GPWS) warning or terrain awareness and warning system (TAWS) warning.

6. Emergency Communication

6.1. In an emergency, the pilot and the controller must communicate clearly and concisely, as suggested below.

6.2. The standard ICAO phraseology "Pan Pan" or "Mayday" must be used by the pilot to alert a controller and trigger an appropriate response.

6.3. Loss of pressurisation is an example of such an emergency; pilots should not delay declaring an emergency in the hope of receiving re-clearance before commencing descent.

6.4. Controllers should recognise that, when faced with an emergency situation, the flight crew's most important needs are:

(a) Time;

(b) Airspace; and,

(c) Silence.

6.5. The controller's response to the emergency situation could be patterned after a memory aid such as ASSIST[2]:

(a) **A**cknowledge:

– Ensure that the reported emergency is understood and acknowledged;

(b) **S**eparate:

– Establish and maintain separation from other traffic and/or terrain;

(c) **S**ilence:

– Impose silence on your control frequency, if necessary; and,

– Do not delay or disturb urgent flight crew action by unnecessary transmissions;

(d) **I**nform:

– Inform your supervisor and other sectors, units and airports, as appropriate;

(e) **S**upport:

– Provide maximum support to the flight crew; and,

(f) **T**ime:

– Allows flight crew sufficient time to handle the emergency.

7. Non-standard Phraseology used within UK

7.1. The UK CAA has adopted certain non-standard phraseology designed to reduce the chance of mishearing or misunderstanding RTF communications. This phraseology is not in accordance with ICAO standards but is based on careful study of the breakdown of pilot/controller communications. The following paragraphs taken from the UK Manual of Radiotelephony[3] summarise the main differences.

(a) The word 'to' is to be omitted from messages relating to FLIGHT LEVELS.

(b) All messages relating to an aircraft's climb or descent to a HEIGHT or ALTITUDE employ the word 'to' followed immediately by the word HEIGHT or ALTITUDE. Furthermore, the initial message in any such RTF exchange will also include the appropriate QFE or QNH.

(c) When transmitting messages containing flight levels each digit shall be transmitted separately. However, in an endeavour to reduce 'level busts' caused by the confusion between some levels (100/110, 200/220 etc.), levels which are whole hundreds e.g. FL 100, 200, 300 shall be spoken as "Flight level (number) HUNDRED". The word hundred must not be used for headings.

7.2. Examples of the above are:

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[2] The ASSIST concept was first employed by ATC at Amsterdam Schiphol Airport.

[3] UK CAA CAP 413 Radiotelephony Manual. See also UK CAA CAP 493 Manual of Air Traffic Services Part 1 and UK CAA Air Traffic Services Information Notice 8/2002 – Phraseology Associated With Clearances Involving Flight Level 100, 200, 300 and 400

(a) "RUSHAIR G-BC climb flight level wun too zero."

(b) "RUSHAIR G-BC descend to altitude tree tousand feet QNH 1014."

(c) "RUSHAIR G-BC climb flight level wun hundred."

(d) "RUSHAIR G-BC turn right heading wun wun zero."

8. Training Program

8.1. A company training program on pilot-controller communications should strive to involve both flight crew and ATC personnel in joint meetings, to discuss operational issues and, in joint flight/ATC simulator sessions, to promote a mutual understanding of each other's working environment, including:

(a) Modern flight decks (e.g. flight management system reprogramming) and ATC equipment;

(b) Operational requirements (e.g. aircraft climb, descent and deceleration characteristics, performance, limitations); and,

(c) Procedures for operating and threat and error management (e.g. standard operational procedures [SOPs]) and instructions (e.g. CRM).

8.2. Special emphasis should be placed on pilot-controller communications and task management during emergency situations.

9. Summary

9.1. The following should be emphasised in pilot-controller communications:

(a) Observe the company SOPs for cross-checking communications;

(b) Recognise and understand respective pilot and controller working environments and constraints;

(c) Use standard phraseology;

(d) Always confirm and read back appropriate messages;

(e) Request clarification or confirmation, when in doubt;

(f) Question an incorrect clearance or inadequate instruction;

(g) Prevent simultaneous transmissions;

(h) Listen to party-line communications as a function of the flight phase;

(i) Use clear and concise communications in an emergency.

10. Resources

Other Level Bust Briefing Notes

10.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 3 – Callsign Confusion;

OPS 1 – Standard Operating Procedures;

OPS 2 – Altimeter Setting Procedures;

OPS 3 – Standard Calls;

ATM 1 – Understanding the Causes of Level Busts;

ATM 2 – Reducing Level Busts.

Access to Resources

10.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory Resources

10.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

10.4. Reference regarding pilot/controller communications can be found in many international and national publications, such as:

ICAO – Annex 6 – Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes, Appendix 2, 5.15;

ICAO Doc 4444 – Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-ATM);

ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I – Flight Procedures;

ICAO – Annex 10 – Volume II: Communication procedures, Chapter 5: Aeronautical Mobile Service;

ICAO Doc 9432 – Manual of Radiotelephony;

Training Material and Incident Reports

EUROCONTROL Level Bust Workshops – Level Bust: Case Studies;

FAA Report – An Analysis of Ground Controller-Pilot Voice Communications;

FSF ALAR Toolkit – Briefing Note 2.3 – Effective Pilot/Controller Communications;

FSF Accident Prevention Volume 57 No 10 – ATR Strikes Mountain on Approach in Poor Visibility to Pristina, Kosovo

Training Material – Posters

Level Bust Prevention posters produced by the UK CAA:

2 Many Things

Wun Wun Zero

Other Resources

FSF Digest June 1993 – Research Identifies Common Errors behind Altitude Deviation;

FSF Accident Prevention Volume 47 No 6 – My Own Mouth shall Condemn Me;

FSF Accident Prevention Volume 49 No 5 – Communication Creates Essential Bond to Allow Air Traffic System to Function Safely;

IATA Report – English Language in Civil Aviation;

NASA feature "One Zero ways to Bust an Altitude … or was that Eleven Ways?";

RAe Human Factors Conference – Level Busts: Considerations for Pilots and Controllers;

UK CAA CAP 710 – "On the Level" and associated recommendations;

UK CAA Air Traffic Services Information Notice 8/2002 – Phraseology Associated With Clearances Involving Flight Level 100, 200, 300 and 400;

UK CAA CAP 413 Radiotelephony Manual;

UK CAA CAP 493 Manual of Air Traffic Services Part 1;

UK CAA Flight Operations Department Communication 11/2000 – Understanding and Interpreting Phraseology and Procedures used by AirTraffic Service Providers;

UK NATS Incidents around Stacks – a Pilot's View.

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GEN 3
Callsign Confusion

1. Introduction

1.1. The use of similar callsigns by aircraft operating in the same area and especially on the same RTF frequency often gives rise to potential and actual flight safety incidents. This hazard is usually referred to as “callsign confusion”.

1.2. The danger of an aircraft taking and acting on a clearance intended for another is obvious. The following are some of the potential outcomes of such a situation:

(a) The aircraft takes up a heading or routing intended for another;

(b) The aircraft commences a climb or descent to a level to which it has not been cleared;

(c) The aircraft departs the RTF frequency of its controller;

(d) In responding to the message, the aircraft blocks a transmission from the intended recipient;

(e) The intended recipient does not receive the clearance, and fails to take up the desired heading or routing, or fails to climb or descent to the desired level;

(f) The workload of controllers and pilots is increased due to the necessity to resolve the confusion.

1.3. Any of the above situations could result in a loss of separation, a level bust, an AIRPROX, or a mid-air collision.

1.4. The purpose of this briefing note is to recommend the best courses of action for aircraft operators, pilots and air traffic controllers in order to minimise the risk of callsign confusion.

1.5. This briefing note draws heavily on the studies referred to in paragraphs 2.2, 2.3 and 2.4 below.

2. Statistical Data

2.1. The UK CAA reported[1] that of a total of 5,625 safety occurrences notified to them during 1997, 175 involved callsign confusion.

2.2. In the same year, the ACCESS[2] initiative collected a total of 482 reports of callsign similarity filed by pilots and air traffic controllers in UK. 217 of these involved actual confusion, including 99 where ATC were actually confused. 353 involved increased reported controller workload by reducing controllers’ thinking time, and increasing RTF usage time.

2.3. During 2003, about 800 safety occurrences reports concerning similar callsigns were collected by air traffic management (ATM) services in France. These include 100 or so incidents having a direct impact on air traffic safety and leading to very unsafe situations (AIRPROX, STCA alerts, level busts and clearance misunderstanding).

2.4. In co-operation with the Netherlands Research Laboratory (NLR), EUROCONTROL studied 444 occurrences[3] in which there were problems with communication between the controller and the pilot. All these occurrences were classified as “incidents[4]”.

2.5. The above occurrences were classified by their consequences. 70 were classified as “wrong aircraft accepted clearance” and 92 as “altitude deviation[5]”. In 19 cases, where the wrong aircraft accepted a clearance an altitude deviation resulted.

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[1] CAP 701 – Aviation Safety Review 1990-1999

[2] CAP 704 – Aircraft Callsign Confusion Evaluation Safety Study. A summary of this report may be found in UK CAA Air craft Information Circular (AIC) 107/2000.

[3] Air-Ground Communication Safety Study: An Analysis of Pilot-Controller Communications.

[4] An incident is defined in ICAO Annex 13 as an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

[5] In this study, an altitude deviation was defined as a departure from, or failure to attain, an altitude assigned by ATC.

3. Studies of Callsign Confusion

3.1. Recent European studies of callsign confusion have had broadly similar findings. The following brief summary of the ACCESS study, referred to in paragraph 2.2 above, is typical.

3.2. The following is a break-down of the main types of occurrence:

(a) 66% of occurrences involved 2 or more aircraft from the same airline;

(b) Nearly half of all occurrences involved UK airlines only, and a third involved foreign aircraft only;

(c) 89% of actual confusion reports occurred either in the climb, the descent or the cruise phase of flight;

(d) 73% of occurrences involved an increase in ATC workload;

(e) Most occurrences took place between 0600 and 1759 hrs.;

(f) The majority of occurrences took place in TMAs or UARs.

3.3. Of the callsign confusion occurrences,

(a) 84% involved numeric[6] only callsigns;

(b) 10% involved alphanumeric[6] callsigns only;

(c) 4% involved a combination of numeric and alphanumeric callsigns.

3.4. The most common identical numeric callsign suffixes were: 101, 202, 333, 37, 837, 762 and 964.

4. Aircraft Callsigns

4.1. Before proceeding with an examination of the callsign confusion problem the rules governing the use of aircraft callsigns will be reviewed. These rules are laid down in ICAO Annex 10[7]. Relevant paragraphs are summarised below.

4.2. Three different types of aircraft callsign may be encountered, as follows:

Type (a) The characters corresponding to the registration marking of the aircraft (e.g. ABCDE). The name of the aircraft manufacturer or model may be used as a prefix (e.g. AIRBUS ABCDE);

Type (b) The telephony designator[8] of the aircraft operating agency, followed by the last four characters of the registration marking of the aircraft (e.g. RUSHAIR BCDE);

Type (c) The telephony designator of the aircraft operating agency, followed by the flight identification (e.g. RUSHAIR 1234).

4.3. The full callsign must be used when establishing communications.

4.4. After satisfactory communication has been established, abbreviated callsigns may be used provided that no confusion is likely to arise; however, an aircraft must use its full callsign until after it has been addressed by the ground station using the abbreviated callsign.

4.5. Callsigns may be abbreviated only in the manner shown below. Examples of full and abbreviated callsigns are shown on Table 1 below.

Table 1 – Examples of Full Callsigns and Abbreviated Callsigns

	Type (a)		Type (b)	Type (c)
Full Callsign	ABCDE	AIRBUS ABCDE	RUSHAIR ABCDE	RUSHAIR 1234
Abbreviated Callsign	ADE or ACDE	AIRBUS DE or AIRBUS CDE	RUSHAIR DE or RUSHAIR CDE	No abbreviated form.

6 A numeric callsign is one in which the suffix consists of numbers only (e.g. RUSHAIR 1234). An alphanumeric callsign is one in which the callsign consists of numbers followed by one or more letters.

7 ICAO Annex 10, Volume II, Section 5.2.1.7.

8 The telephony designators referred to in (b) and (c) are contained in ICAO Doc 8585 — Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services.

Type (a) The first character of the registration and at least the last two characters of the full callsign (the name of the aircraft manufacturer or model may be used in place of the first character);

Type (b) The telephony designator of the aircraft operating agency, followed by at least the last two characters of the call sign;

Type (c) No abbreviated form.

4.6. Most airline callsigns belong to type (c) for which there is no abbreviation. Therefore, abbreviations such as “RUSHAIR 34” are not permissible.

4.7. An aircraft is not permitted to change the type of its call sign during flight, except temporarily on the instruction of an air traffic control unit in the interests of safety.

4.8. In order to avoid any possible confusion, when issuing ATC clearances and reading back such clearances, controllers and pilots must always add the call sign of the aircraft to which the clearance applies.

5. Numeric v Alphanumeric Callsigns

5.7. Many airlines continue to use their IATA commercial flight numbers as callsign suffixes. However, because they tend to be allocated in batches of sequential and very similar numbers, callsign confusion occurs.

5.8. Several airlines have switched to alphanumeric callsigns reasonably successfully in recent years. However, if every operator adopts alphanumeric callsigns, the limited choices available within the maximum of 4 elements allowed within a callsign suffix means that callsign confusion, similar to the existing numeric system, is likely to result.

5.9. Before changing to an effective all alphanumeric callsign system, which involves a significant amount of work, it is recommended that operators review their existing numeric callsign system to deconflict any similar numeric callsigns. Where there is no solution to those callsigns that have a potential for numeric confusion, alphanumeric callsigns can be adopted.

6. Selection of Callsigns

6.1. The best defence against callsign confusion consists in eliminating, or reducing to an absolute minimum, the chance of having two (or more) aircraft with phonetically similar callsigns monitoring the same RTF frequency at the same time.

6.2. To be effective, such a strategy requires action on a regional and international basis. Callsign suffixes must be allocated according to a deliberate, coordinated policy that prevents a confliction arising in the first place.

6.3. Until such a strategy is in place, aircraft operators should attempt to assign callsigns in such a way that confliction with their own and other scheduled traffic does not arise.

6.4. In allocating callsigns, aircraft operators should where possible observe the following recommendations:

(a) Avoid the use of similar numeric callsigns within the company. Effectively, this means, do not use commercial flight numbers as callsigns;

(b) Co-ordinate with other operators to reduce to a minimum any similar numeric and alphanumeric elements of callsigns;

(c) Start flight number element sequences with a higher number (e.g. 6);

(d) Do not use callsigns involving four digits and, wherever possible, use no more than three digits;

(e) Do not use the same digit repeated (e.g. RUSHAIR 555);

(f) If alphanumeric suffixes are to be used, co-ordinate letter combinations with other airspace and airport users;

(g) Do not use alphanumeric callsigns which correspond to the last two letters of the destination’s ICAO location indicator (e.g. RUSHAIR 25LL for a flight inbound to London Heathrow);

(h) Use some numeric and some alphanumeric callsigns (rather than all numeric or all alphanumeric);

(i) If similar numbered callsigns are inevitable, allow a significant time and/or geographical split between aircraft using similar callsigns;

(j) When useful capacity in the allocation of callsigns has been reached, apply for and use a second company callsign designator;

(k) Do not use similar/reversed digits/letters in alphanumeric callsigns (e.g. RUSHAIR 87MB and RUSHAIR 78BM).

6.5. Where commercial flight numbers are not used, operators should ensure that airport information systems can cope with the conversion of RTF callsigns (for ATC use) to commercial flight numbers (for passenger and airport use).

7. Additional Recommendations for Aircraft Operators

7.1. Aircraft operators should have a system to review and if necessary, amend callsigns.

8. Recommendations for Flight Crew

8.1. Always use headsets, especially during times of high RTF loading.

8.2. Do not clip transmissions.

8.3. Use full RTF callsign at all times.

8.4. Use correct RTF procedures and discipline at all times.

8.5. If in doubt about an ATC instruction, do not use readback for confirmation. Instead, positively confirm instructions with ATC. This procedure should also be followed if any doubt exists between flight crew members.

8.6. Question unexpected instructions for any stage of flight.

8.7. Take extra care when members of the flight crew are involved in other tasks and may not be monitoring the RTF.

8.8. At critical stages of flight actively monitor ATC instructions and compliance with them.

8.9. Advise ATC if any of the following situations are observed:

(d) Two or more aircraft with similar callsigns are on the RTF frequency;

(e) It is suspected that an aircraft has taken a clearance not intended for it;

(f) It is suspected that another aircraft has misinterpreted an instruction;

(g) A blocked transmission is observed.

8.10. Although not an official procedure, many pilots hearing that two transmissions block each other call out “Blocked”, after which all transmitting parties try once more to pass their messages.

8.11. After a flight where an actual or potential callsign confusion incident is observed, file a report using the national mandatory incident reporting system or voluntary incident reporting system as appropriate.

9. Recommendations for ATM

9.1. Ensure that aircraft operators are made aware of any actual or potential callsign confusion reported by air traffic controllers.

10. Recommendations for Air Traffic Controllers

10.1. Use correct RTF phraseology, procedures and discipline at all times.

10.2. Do not clip transmissions.

10.3. Ensure clearances are read back correctly. Do not use readback time to execute other tasks.

10.4. Monitor flight crew compliance with RTF callsign use.

10.5. Take extra care when language difficulties may exist.

10.6. Advise adjacent sectors/airports if it is felt that potential confusion may exist between aircraft likely to enter their airspace.

10.7. Warn the pilots of aircraft on the same RTF frequency having similar callsigns that callsign confusion may occur. If necessary, instruct one or both aircraft to use alternative callsigns while they are on the frequency.

10.8. A transmission could be blocked when two or more aircraft are responding to the same clearance. Typically the controller would hear a partial or garbled readback. If a blocked transmission is suspected, ensure that both aircraft retransmit their messages and confirm that a clearance has not been taken by an aircraft for which it was not intended.

10.9. Where an actual or potential callsign confusion incident is observed, file a report using the national mandatory incident reporting system or voluntary incident reporting system as appropriate.

11. Resources

Other Level Bust Briefing Notes

11.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communication;

OPS 1 – Standard Operating Procedures;

ATM 2 – Reducing Level Busts.

Access to Resources

11.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory Resources

11.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO – Annex 10 – Aeronautical Telecommunications, Volume II – Communication Procedures including those with PANS status, Chapter 5 – Aeronautical Mobile Service Voice Communications, Section 5.2.1.7.;

ICAO Doc 8585 — Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services;

ICAO Doc 9432 – Manual of Radiotelephony.

Training Material and Incident Reports

EUROCONTROL Level Bust Workshops – Level Bust: Case Studies;

EUROCONTROL Level Bust Workshops – Level Bust: Causal Factors;

EUROCONTROL Safety Letter – Reducing Level Bust;

FSF ALAR Toolkit – Briefing Note 2.3 – Effective Pilot/Controller Communications.

Other Resources

FAA Report – An Analysis of Ground Controller-Pilot Voice Communications;

FSF Digest June 1993 – Research Identifies Common Errors behind Altitude Deviation;

FSF Accident Prevention Volume 47 No 6 – My Own Mouth shall Condemn Me;

RAe Human Factors Conference – Level Busts: Considerations for Pilots and Controllers;

UK CAA Aeronautical Information Circular (AIC) 107/2000 – Callsign Confusion;

UK CAA CAP 710 – "On the Level" and associated recommendations.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

OPS 1
Standard Operating Procedures

1. Introduction

1.1. Adherence to standard operating procedures (SOPs) is an effective method of preventing level busts, including those that lead to controlled flight into terrain (CFIT).

1.2. Crew resource management (CRM) is not effective without adherence to SOPs.

2. Manufacturer's SOPs

2.1. SOPs published by an aircraft manufacturer are designed to:

(a) Reflect the manufacturer's flight deck design philosophy and operating philosophy;

(b) Promote optimum use of aircraft design features; and,

(c) Apply to a broad range of company operations and environments.

2.2. The initial SOPs for a new aircraft model are based on the manufacturer's objectives and on the experience acquired during flight-testing programs and route-proving programs.

2.3. After they are introduced into service, SOPs are reviewed periodically and are improved based on feedback received from users (in training and in line operations).

3. Customised SOPs

3.1. An aircraft manufacturer's SOPs can be adopted by a company without amendment, or can be used to develop customised SOPs.

3.2. Changes to the airframe manufacturer's SOPs should be co-ordinated with the manufacturer and should be approved by the appropriate authority.

3.3. SOPs must be clear and concise; expanded information should reflect the company's operating philosophy and training philosophy.

3.4. The Flight Safety Foundation (FSF) developed a Standard Operating Procedures Template[1] adapted from the Federal Aviation Administration (FAA) Advisory Circular 120-71 – *Standard Operating Procedures for Flight Deck Crewmembers*. Appendix 1 to JAR-OPS 1.1045, Section 8 lists matters that should be the subject of SOPs but does not include a comparable SOP template.

3.5. The FSF template is a valuable aid in developing company SOPs, but operators should be aware of the differences between FARs and JAR-OPS when using this document. Company SOPs are usually developed to ensure standardisation among different aircraft fleets operated by the company.

3.6. Company SOPs should be reassessed periodically, based on revisions of the airframe manufacturer's SOPs and on internal company feedback, to identify any need for change.

3.7. Flight crews and cabin crews should participate with flight standards personnel in the development and revision of company SOPs to:

(a) Promote constructive feedback; and,

(b) Ensure that the SOPs, as well as the reasons for their adoption, are fully understood by users.

4. Scope of SOPs

4.1. The primary purpose of SOPs is to identify and describe the standard tasks and duties of the flight crew for each flight phase.

4.2. SOPs are generally performed from memory, but tasks related to the selection of systems and to the aircraft configuration should be cross-checked using normal checklists.

4.3. SOPs are usually supplemented by information about specific operating techniques or by

[1] Flight Safety Foundation Standard Operating Procedures Template – see FSF ALAR Toolkit, pages 6-8

recommendations for specific types of operations (e.g. operation on wet runways or contaminated runways, extended-range twin-engine operations [ETOPS] and/or operation in reduced vertical separation minima [RVSM] airspace).

4.4. SOPs assume that all aircraft systems are operating normally and that all automatic functions are used normally. (A system may be partially inoperative or totally inoperative without affecting the SOPs.)

4.5. SOPs should emphasise the following items:

(a) Operating philosophy;

(b) Task-sharing;

(c) Optimum use of automation;

(d) Sound airmanship;

(e) Standard calls[2];

(f) Normal checklists;

(g) Briefings;

(h) Altimeter-setting and cross-checking procedures[3];

(i) Descent profile management;

(j) Energy management;

(k) Terrain awareness;

(l) Radio altimeter;

(m) Level bust awareness.

5. General Principles

5.1. SOPs should contain safeguards to minimise the potential for inadvertent deviations from SOPs, particularly when operating under abnormal conditions or emergency conditions, or when interruptions/distractions occur.

5.2. Safeguards include:

(a) Action blocks – groups of actions being accomplished in sequence;

(b) Triggers - events that initiate action blocks;

(c) Action patterns – instrument panel scanning sequences or patterns supporting the flow and sequence of action blocks; and,

(d) Standard calls – standard phraseology and terms used for effective crew communication.

Standardisation

5.3. SOPs are the reference for crew standardisation and establish the working environment required for CRM.

Task-sharing

5.4. The following guidelines apply to any flight phase but are particularly important to the high-workload climb-out and approach-and-landing phases.

5.5. The pilot flying (PF) is responsible for controlling the horizontal flight path and the vertical flight path, and for energy management, by:

(a) Supervising autopilot operation and autothrottle operation (maintaining awareness of the modes armed or selected, and of mode changes); or,

(b) Hand-flying the aircraft, with or without flight director (FD) guidance, and with an appropriate navigation display (e.g., horizontal situation indicator [HSI]).

5.6. The pilot not flying (PNF) (pilot monitoring) is responsible for monitoring tasks and for performing the actions requested by the PF; this includes:

(a) Performing the standard PNF tasks:

– SOP actions; and,

– FD and flight management system (FMS) mode selections and target entries (e.g. altitude, airspeed, heading, vertical speed, etc.), when the PF is hand- flying the aircraft;

(b) Monitoring systems and aircraft configuration; and,

(c) Cross-checking the PF to provide backup as required (this includes both flight operations and ground operations).

Automation

5.7. With higher levels of automation, flight crews have more options and strategies from which to select for the task to be accomplished.

5.8. Company SOPs should define accurately the options and strategies available for the various phases of flight and for the various types of approach.

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[2] See Briefing Note OPS 3 – Standard Calls

[3] See also Briefing Note OPS 2 – Altimeter Setting Procedures.

Briefings

5.9. The importance of briefing techniques is often underestimated, although effective briefings enhance crew standardisation and communication.

5.10. An interactive briefing style – e.g. confirming the agreement and understanding of the pilot not flying (PNF) after each phase of the briefing – will provide a more effective briefing than an uninterrupted recitation terminated by a final query, "Any questions?"

5.11. An interactive briefing fulfils two important purposes:

(a) To provide the pilot flying (PF) and PNF with an opportunity to correct each other; and,

(b) To share a common mental image of the phase of flight being briefed.

5.12. The briefing should be structured (i.e. follow the logical sequence of the departure, approach and landing, etc.) and concise.

5.13. Routine and formal repetition of the same information on each flight may become counterproductive; adapting and expanding the briefing by highlighting the special aspects of the departure or approach, or the actual weather conditions, will result in more effective briefings.

5.14. Whether anticipated or not, changes in an ATC clearance, weather conditions, or runway in use require a partial review of the briefing.

6. Training

6.1. Disciplined use of SOPs and normal checklists should begin during transition training, because habits and routines acquired during transition training have a lasting effect.

6.2. Transition training and recurrent training provide a unique opportunity to discuss the reasons for SOPs and to discuss the consequences of failing to adhere to them.

6.3. Conversely, allowing deviations from SOPs and/or normal checklists during initial training or recurrent training may encourage deviations during line operations.

7. Deviations from SOPs

7.1. To ensure adherence to published SOPs, it is important to understand why pilots intentionally or inadvertently deviate from SOPs.

7.2. In some intentional deviations from SOPs, the procedure that was followed in place of the SOP seemed to be appropriate for the prevailing situation.

7.3. The following factors and conditions are often cited in discussing deviations from SOPs:

(a) Inadequate knowledge or failure to understand the procedure (e.g., wording or phrasing was not clear, or the procedure was perceived as inappropriate);

(b) Insufficient emphasis during transition training and recurrent training on adherence to SOPs;

(c) Inadequate vigilance (e.g. fatigue);

(d) Interruptions (e.g. communication with air traffic control);

(e) Distractions (e.g., flight deck activity);

(f) Task saturation;

(g) Incorrect management of priorities (e.g., lack of a decision-making model for time-critical situations);

(h) Reduced attention (tunnel vision) in abnormal conditions or high-workload conditions;

(i) Inadequate CRM (e.g., inadequate crew co-ordination, cross-check and backup);

(j) Company policies (e.g., schedules, costs, go-arounds and diversions);

(k) Other policies (e.g., crew duty time);

(l) Personal desires or constraints (e.g., schedule, mission completion);

(m) Complacency; and,

(n) Overconfidence.

7.4. These factors may be used to, assess company exposure to deviations and/or personal exposure to deviations, and to develop corresponding methods to help prevent deviations from SOPs.

8. Summary

8.1. Deviations from SOPs occur for a variety of reasons; intentional deviations and inadvertent deviations from SOPs have been identified as causal factors in many level bust incidents.

8.2. CRM is not effective without adherence to SOPs, because SOPs provide a standard reference for the crew's tasks on the flight deck. SOPs are effective only if they are clear and concise.

8.3. Transition training provides the opportunity to establish the disciplined use of SOPs, and recurrent training offers the opportunity to reinforce that behaviour.

9. Resources

Other Level Bust Briefing Notes

9.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

OPS 2 – Altimeter Setting Procedures;

OPS 3 – Standard Calls;

OPS 4 – Aircraft Technical Equipment;

OPS 5 – Airborne Collision Avoidance Systems.

Access to Resources

9.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory References

9.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 6 Part I Appendix 2 – Contents of an Operations Manual;

ICAO Doc 8168 – Procedures for Air Navigation Services – Operations (PANS-OPS);

ICAO Doc 9376 – Preparation of an Operations Manual;

JAR-OPS 1.1040 – Sub-part P and associated AMCs and IEMs – General Rules for Operations Manuals;

JAR-OPS 1.1045 – Sub-part P and associated AMCs and IEMs – Operations Manual – Structure and Contents.

Training Material – Safety Letters

EUROCONTROL Safety Letter – Level Bust: a Shared Issue?;

EUROCONTROL Safety Letter – Reducing Level Bust;

EUROCONTROL Safety Letter – En Route to Reducing Level Bust;

EUROCONTROL Safety Letter – Airborne Collision Avoidance Systems (ACAS);

EUROCONTROL ACAS II Bulletin: "Follow the RA!";

Training Material – Posters

Level Bust Prevention posters produced by the UK CAA:

2 Many Things;

Low QNH – High Risk;

No Rush – No Mistake;

Wun Wun Zero.

Other Training Material

FAA Advisory Circular 120-71 – Standard Operating Procedures for Flight Deck Crewmembers;

Flight Safety Foundation (FSF) Approach and Landing Accident Reduction (ALAR) Toolkit Briefing Note:

1.3 – Operations Golden Rules;

1.4 – Standard Calls;

1.6 – Approach and Go-around Briefings.

FSF Accident Prevention 1/99 – Aircraft Accidents Aren't – Part 2;

FSF Accident Prevention 12/95 – Different Altimeter Displays and Crew Fatigue …;

FSF Accident Prevention 4/98 – Boeing 737 Pilot selects Incorrect Altitude in Holding Pattern….

Other Resources

FSF Digest 7/94 – Sterile Cockpit Compliance;

FSF Digest 12/95 – Altitude Awareness Programs Can Reduce Altitude Deviations;

FSF Digest 3/99 – Enhancing Flight Crew Monitoring Skills;

NASA article – What Goes Up Must Come Down;

UK CAA CAP 710 – "On the Level" & Recommendations.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

OPS 2
Altimeter Setting Procedures

1. Introduction

1.1. Flight crew on international routes encounter different units of measurement for setting barometric altimeters, thus requiring altimeter cross-checking procedures.

2. QNH or QFE?

2.1. QNH is the altimeter setting that causes the altimeter to indicate vertical distance above mean sea level, e.g. airfield elevation at touchdown on the runway.

2.2. QFE is the altimeter setting that causes the altimeter to indicate vertical distance above the QFE reference datum, i.e. zero at touchdown on the runway.

2.3. QNH has the advantage over QFE of eliminating the need to change the altimeter setting during operations below the transition level or transition altitude

2.4. QNH also eliminates the need to change the altimeter setting during a missed approach, whereas such a change would usually be required when QFE is used.

2.5. Some operators set the altimeter to QFE in areas where the air traffic control (ATC) and the majority of other operators use QNH. Standard operating procedures (SOPs) can prevent altimeter setting errors.

3. Units of Measurement

3.1. The most common units of measurement for setting altimeters are:

(a) Hectopascals (hPa), still referred to as millibars (mb) in some countries; and,

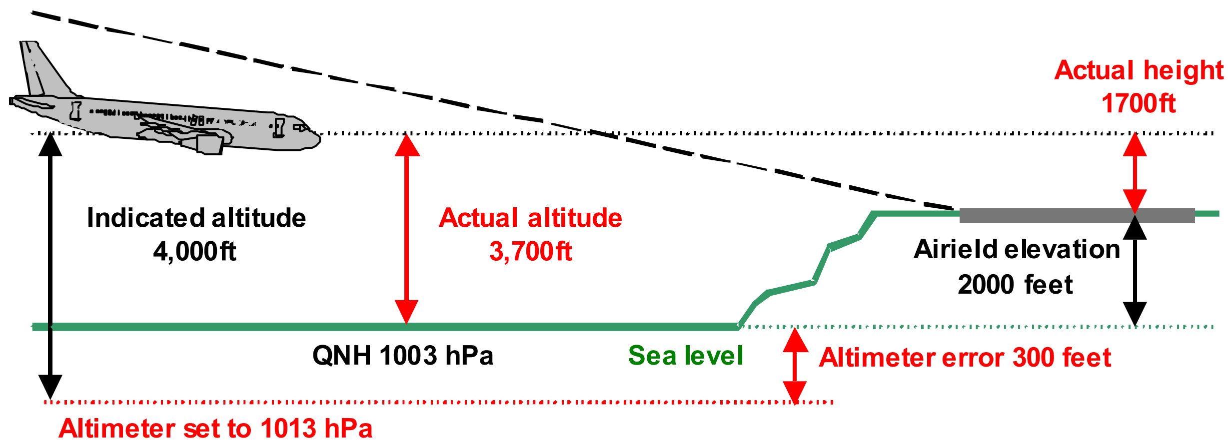
(b) Inches of mercury (in. Hg).

3.2. Throughout Europe, hPa (or mb) is the primary altimeter setting. Within North America, the primary altimeter setting is in.Hg. Elsewhere, either system may be encountered.

3.3. Altimeter settings are occasionally misheard when listening to ATIS or ATC and the error may sometimes go undetected. When hPa is used as altimeter setting, an error of 10 hPa will correspond to approximately 300 feet error in indicated altitude.

3.4. In Figure 1, QNH is 1003 hPa, but the altimeter was mistakenly set to the standard pressure setting, 1013 hPa, resulting in the true altitude (i.e. the aircraft's actual height above mean sea-level) being *300 feet lower than indicated*.

Figure 1 – The Effect of a 10 hPa high Altimeter Setting



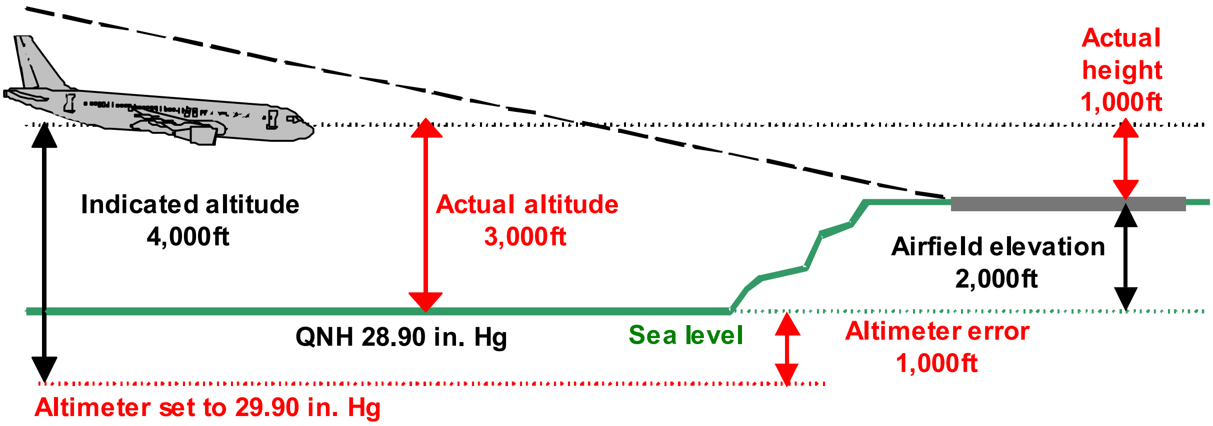
3.5. In this example, an uncorrected error when flying a non-precision approach to land could result in impact with the ground about 1nm before touchdown point.

3.6. When in. Hg is used for altimeter setting, unusual barometric pressures such as 28.XX in. Hg (low pressure) or 30.XX in. Hg (high pressure) may go undetected with more serious results if a more usual 29.XX is erroneously set.

3.7. Figure 2 shows that a 1.00 in. Hg discrepancy in the altimeter setting results in a 1,000 foot error in the indicated altitude.

3.8. In Figure 2, QNH is an unusually low 28.90 in. Hg, but the altimeter was mistakenly set to a more usual 29.90 in. Hg, resulting in the true altitude (i.e. the aircraft's actual height above mean sea-level) being 1,000 feet lower than indicated.

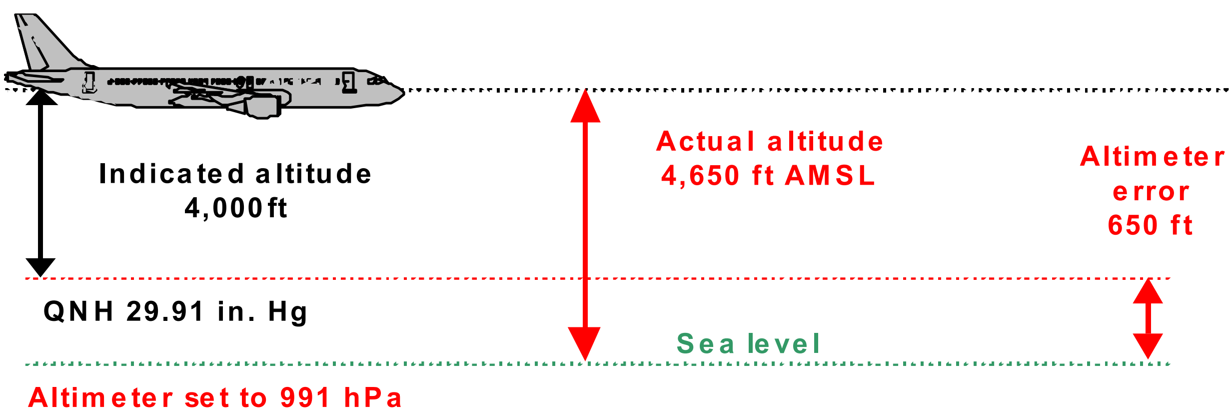
Figure 2 – The Effect of a 1.00 in. Hg High Pressure Setting



3.9. Confusion about units of measurement (i.e. hPa and in. Hg) leads to similar errors.

3.10. In Figure 3, a QNH of 2991 in. Hg was mistakenly set on the altimeter as 991 hPa resulting in the true altitude being *650 feet higher than indicated*.

Figure 3 – The Effect of an Altimeter mis-set to Hectopascals Rather than Inches



4. Setting the Altimeter

4.1. To help prevent errors associated with different units of measurement or with unusual values (low or high), the following SOPs should be used when broadcasting (automated traffic information service [ATIS] or controllers) or reading back (pilots) an altimeter setting:

- All digits, as well as the unit of measurement (e.g. *hectopascals* or *inches*), should be announced.

4.2. A transmission such as “altimeter setting six seven” can be interpreted as 967 hPa, 28.67 in. Hg, 29.67 in. Hg or 30.67 in. Hg.

4.3. Stating the complete altimeter setting prevents confusion and allows detection and correction of previous error.

4.4. An incorrect altimeter setting is often the result of one or more of the following factors:

(a) High workload;

(b) A deviation from defined task sharing;

(c) An interruption or distraction;

(d) Inadequate cross-checking by flight crewmembers; or,

(e) Confusion about units of measurement.

4.5. Adherence to the defined task sharing (for normal or abnormal conditions) and normal checklists are the effective defences to help prevent altimeter setting errors.

5. Metric Altimeter

5.1. Metric altitudes in certain countries (e.g. the Commonwealth of Independent States [CIS] and The People’s Republic of China) also require SOPs for the use of metric altimeters or conversion tables.

6. Crossing the Transition Altitude

6.1. The transition altitude can be either:

(a) Fixed for the whole country (e.g. 18,000 feet in the United States);

(b) Fixed for a given airport (as indicated in the approach chart); or,

6.2. Transition Level may vary, depending on QNH (as indicated in the ATIS broadcast).

6.3. Changing from variable Transition Level to fixed transition altitude may result in a premature or late setting of the altimeter reference (e.g. US aircraft flying into Europe or vice-versa).

6.4. An altitude constraint (expressed in terms of altitude or flight level) may also advance or delay the change of the altimeter reference possibly resulting in crew confusion.

7. Changing Altimeter Setting Reference

7.1. ICAO PANS-OPS[1] requires that the altimeter pressure setting should be changed to the new reference when crossing the transition altitude/level.

7.2. Some national authorities stipulate that, when an aircraft has been cleared to climb from an altitude to a flight level, vertical position will be reported in terms of flight level unless intermediate altitude reports have been specifically requested by ATC. Similarly when a pilot is descending from a flight level to an altitude the pilot will change to the aerodrome QNH unless further flight level vacating reports have been requested by ATC, in which case the QNH will be set following the final flight level vacating report.

7.3. Elsewhere, operators have adopted a similar policy in an attempt to minimise the potential for failing to set the correct pressure setting. This policy takes account of the:

(a) high pilot workload, usually occurring at or around the transition altitude/level;

(b) high rates of climb and descent, which are a feature of modern air transport.

7.4. In countries where the above procedure is in force, controllers must realise that the datum will have been changed, and be prepared to act accordingly.

7.5. Pilots following this procedure must be aware of the consequences in countries where this procedure is not standard if the controller requires the aircraft to level before the cleared flight level/altitude is reached. (e.g. aircraft cleared to descend from FL 100 to altitude 3,000 feet. Transition level FL 40. Pilot will set QNH and commence descent. If controller subsequently requires the aircraft to level at FL 60 the standard pressure setting must be reset.)

[1] ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I, Flight Procedures – Part VI – Altimeter Setting Procedures – Chapter 3

8. Summary

8.1. Altimeter-setting errors are a common cause for level busts and result in a lack of vertical situational awareness. The following minimise the potential for altimeter-setting errors:

(a) Awareness of altimeter setting changes demanded by prevailing weather conditions (extreme cold fronts, steep frontal surfaces, semi-permanent low pressure areas or seasonal low pressure areas);

(b) Awareness of the unit of measurement for setting the altimeter at the destination airport;

(c) Awareness of the anticipated altimeter setting, (based on aviation routine weather reports [METARs] and ATIS broadcasts);

(d) PF/PNF cross-checking;

(e) Adherence to SOPs for:

– Resetting altimeters at the transition altitude/level;

– Using the standby altimeter to cross-check the primary altimeters;

– Altitude calls.

9. Resources

Other Level Bust Briefing Notes

9.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

OPS 1 – Standard Operating Procedures;

OPS 4 – Aircraft Technical Equipment;

ATM 1 – Understanding the Causes of Level Busts.

Access to Resources

9.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from *ICAO*;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from *FSF*;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from *JAA*.

Regulatory References

9.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 3 – Meteorological Service for International Air Navigation, Chapter 4;

ICAO Annex 5 – Units of Measurement to be used in Air and Ground Operations, Table 3-4, 3.2.

ICAO Annex 6 – Operations of Aircraft, Part I – International Commercial Air Transport – Aeroplane, 6.9.1 c) and Appendix 2, 5.13;

ICAO Doc 4444 – Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-ATM);

ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I, Flight Procedures – Part VI – Altimeter Setting Procedures – Chapter 3;

ICAO Doc 9376 – Preparation of an Operations Manual.

Training Material & Incident Reports

FSF Approach & Landing Accident Reduction (ALAR) Toolkit:

Briefing Note 3.1 – Barometric Altimeter & Radio Altimeter;

ICAO Video – Altimetry – Basic Principles;

ICAO Audioslides – Altimetry – Basic Principles;

ICAO Poster – Altimeter Setting Procedures;

UK CAA Poster: Low QNH – High Risk;

FSF Accident Prevention 54/1 – Learjet MEDEVAC Flight ends in CFIT Accident.

Other Resources

FSF Digest 6/93 – Research Identifies Common Errors behind Altitude Deviation;

NASA – International Altimetry;

The Bluecoat Forum – Avoiding Level Busts;

UK CAA CAP 710 – On the Level & Recommendations.

Level Bust Briefing Notes
Aircraft Operators

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

OPS 3
Standard Calls

1. Introduction

1.1. Standard phraseology is essential to ensure effective crew communication, particularly in today's operating environment, which increasingly features:

(a) Two-person crew operation; and,

(b) Crewmembers from different cultures and with different native languages.

1.2. Standard calls – commands and responses – are designed to enhance overall situational awareness (including awareness of the status and the operation of aircraft systems).

1.3. Standard calls may vary among aircraft models, based upon flight deck design and system designs, and among company standard operating procedures.

2. Use of Standard Calls

2.1. Standard calls should be *alerting*, so that they are clearly identified by the pilot flying (PF) or pilot not flying (PNF) (pilot monitoring) and should be distinguished from communication within the flight deck or between pilots and controllers.

2.2. Standard calls reduce the risk of tactical (short-term) decision making errors (in selecting modes, or entering targets [e.g. airspeed, heading, altitude] or in setting configurations).

2.3. The importance of using standard calls increases with increased workload.

2.4. Standard calls should be practical, concise, clear and consistent with the aircraft design and operating philosophy.

2.5. Standard calls should be included in the flow sequence of manufacturer's SOPs or the company's SOPs and with the flight-pattern illustrations in the aircraft's operating manual (AOM).

2.6. Standard calls should be performed in accordance with the defined PF/PNF task sharing (i.e., task sharing for hand flying versus autopilot operation, or task sharing for normal condition versus abnormal/ emergency condition).

2.7. Nevertheless, if a call is omitted by one pilot, the other pilot should suggest the call, as per good crew resource management (CRM) practice.

2.8. The absence of a standard call at the appropriate time or the absence of acknowledgement may be the result of a system malfunction, or equipment malfunction, or possible incapacitation of the other pilot.

2.9. Standard calls should be used to:

(a) Give a command (delegate a task) or transfer a piece of information;

(b) Acknowledge a command or confirm receipt of information;

(c) Give a response or ask a question (feedback);

(d) Call a change of indication (e.g. a flight mode annunciator [FMA] mode change); or,

(e) Identify a specific event (e.g. crossing an altitude or flight level).

3. General Standard Calls

3.1. The following are standard calls:

(a) "Check" (or "verify"): a command for the other pilot to check or verify an item;

(b) "Checked": a confirmation that an item has been checked;

(c) "Cross-check(ed)": a confirmation that information has been checked at both pilot stations;

(d) "Set": a command for the other pilot to enter a target value or a configuration;

(e) “Arm”: a command for the other pilot to arm a system (or a mode);

(f) “Engage”: a command for the other pilot to engage a system or select a mode; and,

(g) “On” (or “Off”) following the name of a system: a command for the other pilot to select (or deselect) the system; or a response confirming the status of the system.

(h) Where a target value is set or checked, a statement of the value should precede the ‘set/checked’ call (e.g. “Altimeter 29.92 set”. Or “Autopilot engaged, alt sel 9000ft set”).

4. Specific Standard Calls

4.1. Specific standard calls should be defined for the following events:

(a) Flight crew-ground mechanics communications;

(b) Engine start sequence;

(c) Landing gear and slats/flaps selection (retraction or extension);

(d) Initiation, interruption, resumption and completion of normal checklists;

(e) Initiation, sequencing, interruption, resumption and completion of abnormal checklists and emergency checklists;

(f) FMA mode changes;

(g) Changing the altimeter setting;

(h) Approaching the cleared altitude or flight level;

(i) Airborne Collision Avoidance System (ACAS) traffic advisory (TA) or resolution advisory (RA);

(j) PF/PNF transfer of controls;

(k) Excessive deviation from a flight parameter;

(l) Specific points along the instrument approach procedure;

(m) Approaching minima and reaching minima;

(n) Acquisition of visual references; and,

(o) Decision to land or to go-around.

4.2. *The use of standard calls is of paramount importance for optimum use of automation* (autopilot, flight director and autothrottle mode arming or mode selection, target entries, FMA annunciations, flight management system [FMS] mode selections):

(a) Standard calls should immediately trigger the question “What do I want to fly now?“, and thus clearly indicate which:

– mode the pilot intends to arm or select; or,

– target the pilot intends to enter; and,.

(b) When the intention of the PF is clearly transmitted to the PNF, the standard call will also:

– Facilitate the cross-check of the FMA (and primary flight display or navigation display as applicable); and,

– Facilitate crew co-ordination, cross-checking and backup.

4.3. Standard calls should also be defined for flight crew/cabin crew communication in both:

(a) Normal conditions; and,

(b) Abnormal or emergency conditions (e.g. cabin depressurisation, on-ground emergency/ evacuation, crew incapacitation, forced landing or ditching, etc.).

5. Harmonisation of Standard Calls

5.1. The harmonisation of standard calls across various aircraft fleets (from the same or from different aircraft manufacturers) is desirable but should not be an overriding demand.

5.2. Standard calls across fleets are only essential for crewmembers operating different fleets (i.e. for communications between flight deck and cabin or between flight deck and ground).

5.3. Within the flight deck, pilots must use standard calls appropriate for the flight deck and systems.

5.4. With the exception of aircraft models with flight deck commonality, flight deck layouts and systems are not the same and, thus, differences as well as similarities should be recognised.

5.5. When defining standard calls, standardisation and operational efficiency should be balanced carefully.

6. Summary

6.1. Standard Calls ensure effective crew interaction and communication.

6.2. The command and the response are of equal importance to ensure timely action or correction.

7. Resources

Other Level Bust Briefing Notes

7.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

OPS 1 – Standard Operating Procedures.

Access to Resources

7.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory References

7.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO – Annex 6 – Operation of Aircraft, Part I – International Commercial Air transport – Aeroplanes, Appendix 2, 5.13;

ICAO Doc 9376 – Preparation of an Operations Manual;

JAR-OPS 1.1045 and associated Appendix 1 – Operations Manuals – structure and contents.

Training Material

FSF Approach & Landing Accident Reduction (ALAR) Toolkit Briefing Note 1.4 – Standard Calls.

Other Resources

FSF Digest 3/99 – Enhancing Flight Crew Monitoring Skills Can Increase Flight Safety;

U.S. National Transportation Safety Board (NTSB) – Special Report NTSB-AAS-76-5 – Special Study: Flightcrew Coordination Procedures in Air Carrier Instrument Landing System Approach Accidents.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

OPS 4
Aircraft Technical equipment

1. Introduction

1.1. Aircraft automation and technical equipment may have a direct effect on the likelihood of a level bust. Four types of equipment are concerned. These are:

(a) Barometric altimeters;

(b) Altitude alerters;

(c) Automation; and,

(d) Airborne collision avoidance systems (ACAS).

1.2. Although each of these pieces of equipment can be instrumental in causing a level bust, *correct use of equipment prevents level busts*.

1.3. The overwhelming characteristic of ACAS is its ability to reduce the risk of collision. For this reason, ACAS has been dealt with in full in a separate briefing note.[1]

1.4. Aircraft equipment varies widely according to the age, manufacturer and model; the choice of equipment fitted; and the modification state of the equipment.

1.5. Equipment fitted in states which follow JAR-OPS 1 is governed by regulations. In non-JAR-OPS states, regulatory standards may vary considerably.

2. Barometric Altimeters

Conventional Altimeters

2.1. JAR-OPS[2] requires that aircraft be equipped with two sensitive pressure altimeters calibrated in feet with sub-scale settings, calibrated in hectopascals (or millibars), adjustable for any barometric pressure likely to be set during flight. Not later than 1 April 2002 these altimeters must have counter drum-pointer or equivalent presentation.

2.2. JAA TGL28[3] describes the main types of barometric altimeter presentation in use today. These are: three-pointer; drum-pointer; counter-pointer; and counter drum-pointer.

2.3. Although all commercial air transport aeroplanes operated in JAR-OPS states should now be equipped with primary altimeters featuring the counter drum-pointer presentation, other types of altimeter display may be encountered elsewhere.

2.4. TGL28 explains the shortcomings of the first three types of altimeter which led to the development of the counter drum-pointer instrument.

2.5. The counter drum-pointer presentation is illustrated in Figure 1. In case of doubt, operators should refer to the full description in TGL28.

2.6. JAR-OPS does not specify the type of altimeter display to be fitted as standby equipment, but TGL28 recommends that Operators should use the counter drum-pointer layout.

2.7. TGL28 also recommends that the primary altimeters in use at pilot stations should have similar displays.

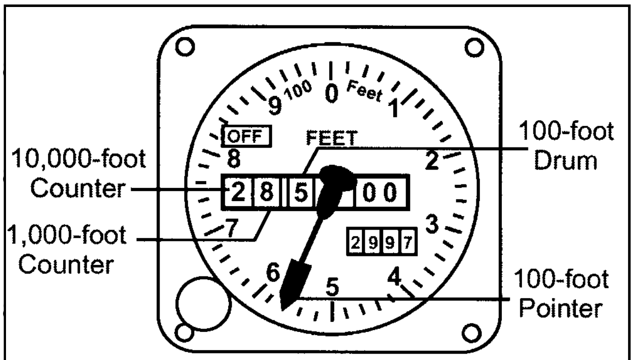


Figure 1

Counter Drum-Pointer Altimeter Display

[1] Briefing Note OPS 5 – Airborne Collision avoidance Systems.
[2] JAR-OPS 1.652(c) – IFR or night operations – Flight and navigational instruments and associated equipment

[3] JAA Administrative & Guidance Material Section Four: Operations, Part Three: Temporary Guidance: Leaflets (JAR-OPS) Leaflet No 28 – Drum-Pointer and Counter/Drum-Pointer Display Altimeters.

Electronic Flight Instrument Displays (EFIS)

2.8. In modern flight decks the altitude displays differ from the conventional altimeter, usually featuring a vertical altitude tape on the right hand side. The rate of climb or descent may be harder to visualise than when using the conventional altimeter, in the same way as reading a digital watch is more error-prone than using an analogue one. In some cases, rate cues such as chevrons have been added to address this problem.

2.9. In particular, JAA TGL11[4] points out that if a vertical speed tape is used and the range of the tape is less than 2,500 ft/min, an ACAS Increase Rate RA cannot be properly displayed.

2.10. Some examples of EFIS altitude displays are shown below to illustrate the wide variety that may be encountered. Each display may have unique aspects requiring specific system knowledge and may require adjustment of the instrument scan to encompass all information.

2.11. With the introduction of new technology there is always opportunity for new errors; flight crews require in depth knowledge of their current displays and operating systems and must be aware that under stress, the human tendency is to revert to a previous or best known mode of operation.

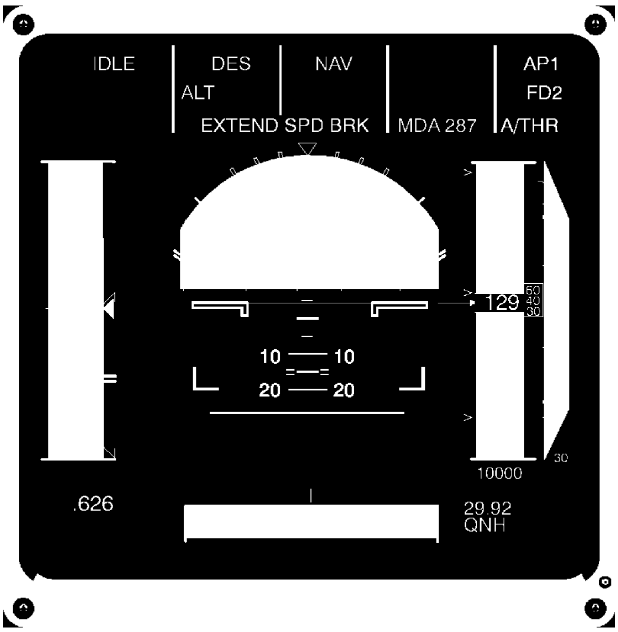


Figure 2a

Figure 2b

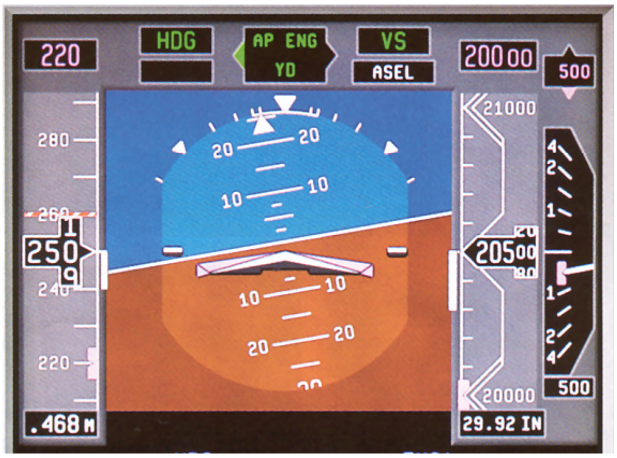


Figure 2c

Figure 2d
(Head-up Guidance System)

[4] JAA Administrative & Guidance Material Section Four: Operations, Part Three: Temporary Guidance: Leaflets (JAR-OPS) Leaflet No. 11: Guidance For Operators On Training Programmes For The Use Of Airborne Collision Avoidance Systems (ACAS)

3. Altitude Alerter

3.1. JAR-OPS[5] requires that aircraft be equipped with an altitude alerting system (see Figure 3) capable of:

(a) Alerting the flight crew upon approaching a preselected altitude; and

(b) Alerting the flight crew by at least an aural signal, when deviating from a preselected altitude.

3.6. The Swedish CAA report[6] found that the altitude alerter had a positive effect on the avoidance of level busts. They also reported that level busts were significantly less likely to occur on aircraft equipped with aural warnings as well as visual warnings.

3.7. In 2000 the UK CAA published the findings of their level bust working group – "On the Level" and in April 2001 a series of further recommendations was published[7] which are worthy of study.

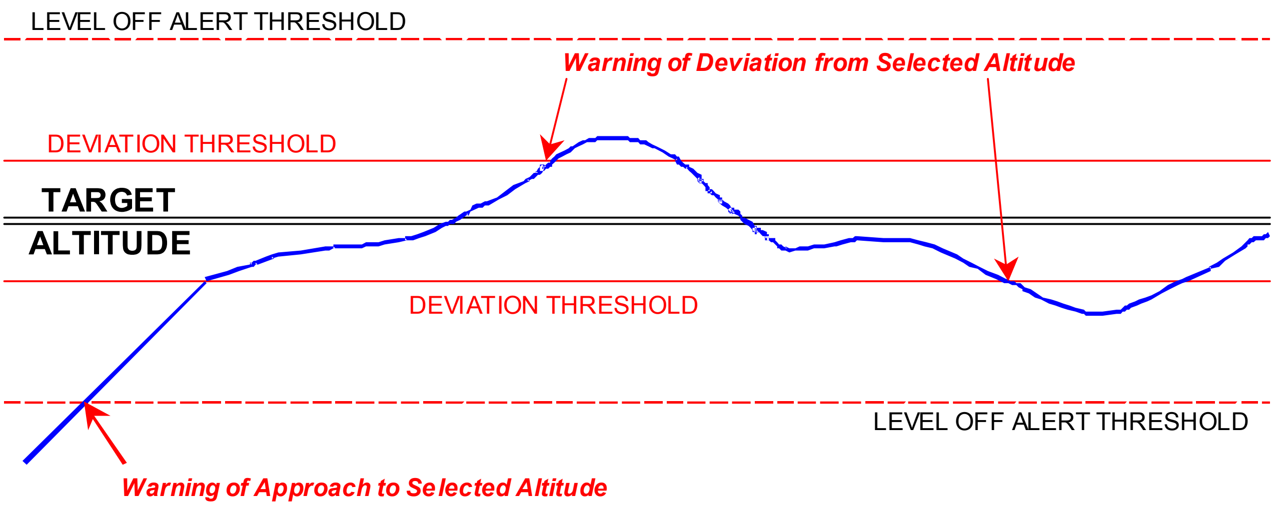


Figure 3.
Approach to or deviation from selected altitude is indicated by a combination of visual and/or aural warnings

3.2. Some altitude alerters are only fitted with visual warnings while others have an aural warning as well as a light.

3.3. Typically, a momentary chime is heard and/or a light comes on at a preset point, usually after the "1000 ft to go" point. The light goes out when the aircraft comes within a specified distance (usually 200 ft – 300 ft) of the preselected altitude.

3.4. If the aircraft deviates by a specified amount (usually 200 ft – 300 ft from the preselected altitude) the light comes on together with an aural tone or a voice message such as "ALTITUDE".

3.5. In 1997 the Swedish Civil Aviation Authority (CAA) reported the results of a survey carried out among major Swedish operators. Their objective was to detect aircraft equipment that had a positive influence on aircraft leveling off at the selected altitude.

4. Automation

8.4. Automatic flight guidance systems (FGS) and flight management systems (FMS) vary widely between aircraft types and even between examples of the same aircraft type. Not only does equipment vary, but the underlying philosophy may differ from one system to another. Unless pilots understand fully the systems fitted to their aircraft, there is a danger of level bust because of incorrect setting or inadequate understanding of mode changes.

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[5] JAR-OPS 1.660 – Altitude Alerting Systems

[6] CAP 710 – UK CAA Level Bust Working Group "On the Level" Project Final Report, (the Swedish report is at Attachment 6

[7] CAP 710 – UK CAA Level Bust Working Group "On the Level" Project Final Report and Recommendations Originating from the "On the Level" project.

Factors and Errors

4.1. The following factors and errors can cause an incorrect flight path, which – if not recognised – can lead to a level bust, including controlled flight into terrain:

(a) Inadvertent arming of a mode or selection of an incorrect mode;

(b) Failure to verify the armed mode or selected mode by reference to the flight mode annunciator (FMA);

(c) Entering the incorrect target altitude on the FGS control panel and failure to confirm the entered target on the primary flight display (PFD) and/or navigation display (ND);

(d) Changing the FGS control panel altitude target to any altitude below the final approach intercept altitude during approach;

(e) Preoccupation with FGS or FMS programming with consequent loss of situational awareness;

(f) Inadequate understanding of mode changes (e.g. mode confusion or automation surprises);

(g) Inadequate task sharing and/or inadequate crew resource management (CRM), preventing the pilot flying (PF) from monitoring the flight path; and,

(h) Engaging the AP or disengaging the AP when the aircraft is in an out-of trim condition.

Operating Philosophy

4.2. Operation of the FGS and FMS must be monitored at all times by:

(a) Cross checking the FGS engagement status and mode of operation on the FMA;

(b) Stating and checking the selected altitude (Alt Sel) value; and,

(c) Monitoring the result of FGS operation by cross-reference to the basic flight displays.

4.3. The PF should always use the most appropriate guidance and level of automation for the task.

4.4. If doubt exists about the aircraft's flight path or airspeed control, no attempt should be made to reprogram the automated systems. Revert to a lower level of automation or hand fly with raw data until time and conditions permit reprogramming the FGS or FMS.

4.5. If the aircraft does not follow the intended flight path, check the FGS engagement status. If engaged, the FGS must be disconnected using the AP-disconnect switch to revert to hand-flying with reference to raw data.

4.6. When hand-flying for any other reason, the FD commands should be followed; otherwise, the FD command bars should be cleared from the PFD.

4.7. FGS systems must not be overridden manually, except under conditions set forth in the aircraft operating manual (AOM) or quick reference handbook (QRH).

4.8. Use an appropriate instrument scan for automatic flight that gives more emphasis to the FGS engaged status and FMA.

Recommendations

4.9. Before engaging the FGS, ensure that:

(a) The modes selected for FD guidance are correct; and,

(b) The FD command bars do not show large flight-path correction commands. If large corrections are commanded, hand-fly the aircraft to centre the FD command bars).

4.10. Before taking action on the FGS control panel check that the knob or push-button is the correct one for the desired function.

4.11. After each action on the FGS control panel, verify the result of the action by reference to the FMA and to other PFD/ND data or by reference to the flight path and airspeed.

4.12. Monitor the FMA and call all mode changes in accordance with SOPs.

4.13. When changing the altitude entered on the FGS control panel, cross-check the selected-altitude readout on the PFD.

4.14. No attempt should be made to analyse or to correct an anomaly by reprogramming the FGS or the FMS until the desired flight path or altitude is restored.

4.15. If at any time the aircraft does not follow the desired flight path, do not hesitate to revert to a lower (more direct) level of automation. For example:

(a) Revert from FMS to selected modes;

(b) Disengage the AP and follow FD guidance;

(c) Disengage the FD, select the flight path vector and fly raw data or fly visually (if in visual meteorological conditions); and/or,

(d) Disengage the A/THR and control the thrust manually.

5. Resources

OtherLevel Bust Briefing Notes

5.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

OPS 1 – Standard Operating Procedures;

OPS 2 – Altimeter Setting Procedures;

OPS 5 – Airborne Collision Avoidance Systems.

Access to Resources

5.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from *ICAO*;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from *FSF*;

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Regulatory References

5.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

JAR-OPS 1.650 & 1.652 – Flight and Navigational Equipment & Associated Equipment;

JAR-OPS 1.660 – Altitude Alerting System.

Training Material & Incident Reports

FSF Accident Prevention No 4/1997: MD83 Descends Below Minimum Descent Height;

NASA Technical Memorandum 92/7 – Altitude Deviations: Breakdown of an Error Tolerant System;

Report by the Norwegian Air Accident Investigation Bureau into an Airprox between an Airbus A310 and a Boeing 737 at Oslo in February 2002.

Other Resources

FSF Digest 11/98 – "Killers in Aviation": Facts about Controlled Flight Into Terrain Accidents;

FSF Digest 6/93 – Research Identifies Common Errors behind Altitude Deviation;

FSF Digest 6/99 – Transition to Glass: Pilot Training for High technology Aircraft;

FSF Accident Prevention 12/95 – Different Altimeter Displays and Crew Fatigue … ;

NASA: Murphi Busts an Altitude – A Murphi Anaysis of an Automation Surprise;

NASA: Pilot-Autopilot Interaction – A Formal Perspective;

UK CAA CAP 710 – "On the Level" and associated recommendations.

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OPS 5

Airborne Collision Avoidance Systems

1. Introduction

1.1. Airborne collision avoidance systems are designed to improve safety by acting as a "last resort" method of preventing mid-air collisions. This is achieved by recommending pilots to manoeuvre in the vertical plane when a risk of collision is detected.

1.2. The concept for an airborne collision avoidance system, which is independent from ATS systems, emerged in 1955. In the early 1980s ICAO started work on the development of standards for an "Airborne Collision Avoidance System" (ACAS). The definition is found in ICAO Annex 10.[1]

1.3. The US FAA made a decision in 1981 to develop and introduce a collision avoidance system capable of recommending evasive manoeuvres in the vertical plane to cockpit crew. This system is called "Traffic Alert and Collision Avoidance System" (TCAS).

1.4. Within Europe, the mandatory carriage and operation of an airborne collision avoidance system is required by defined civil aircraft. European States have enacted legislation which, for flight within their airspace, mandates the carriage of ACAS II for larger aircraft from January 2000, and this requirement is extended to aircraft weighing more than 5700 kg, or having more than 19 passengers seats from 1 January 2005. In line with this, the JAA included ACAS equipment provisions in JAR-OPS 1 regulations.[2]

1.5. Today "TCAS II v.7.0" offers the same functionality as ICAO has specified for ACAS II and in practice, the terms "TCAS" and "ACAS" are used interchangeably. For simplicity, the term "ACAS" will be used to mean "ACAS II" throughout this document.

[1] ICAO Annex 10 Volume IV – Surveillance Radar and Collision Avoidance Systems – Chapter 4 Paragraph 4.1.
[2] JAR-OPS 1.668 – Airborne Collision Avoidance System.

2. ACAS Indications

2.1. ACAS issues two types of warning of potential collision:

(a) A traffic advisory (TA) is issued 20 to 48 seconds before the closest point of approach (CPA) to warn the pilots that an RA may follow and to assist in a visual search for the traffic;

(b) A resolution advisory (RA) is issued 15 to 35 second before CPA which provides the pilots with indication of appropriate vertical manoeuvres, or vertical manoeuvre restrictions, to ensure the safe vertical separation of the ACAS aircraft. However, it should be noted that the vertical separation provided by ACAS is independent of ATC separation standards. This is because ACAS does not seek to ensure separation, which is the role of ATC, but as a last resort, seeks to avoid collision.

3. Operation of ACAS

3.1. The value of ACAS as an accident prevention aid has been amply demonstrated; however, unless sound operating procedures are followed by all pilots, the value of ACAS may be seriously eroded or even negated.

3.2. JAR-OPS[3] requires that when an RA is received, the PF "shall ensure that corrective action is initiated immediately to establish safe separation unless the intruder has been visually identified and has been determined not to be a threat".

3.3. JAA TGL11[4] contains performance-based training objectives for ACAS II pilot training. This includes detailed instructions on the proper reaction to receipt of an ACAS RA or TA.

[3] JAR-OPS 1.398 – Use of Airborne Collision Avoidance System (ACAS).
[4] JAA Administrative & Guidance Material Section Four: Operations, Part Three: Temporary Guidance: Leaflets (JAR-OPS) Leaflet No. 11: Guidance For Operators On Training Programmes For The Use Of Airborne Collision Avoidance Systems (ACAS)

3.4. With regard to pilot response to RAs, TGL11 specifies that:

(a) For corrective RAs, the response must be initiated in the proper direction within 5 seconds of the RA being displayed, and the change in vertical speed must be accomplished with an acceleration of approximately ¼g;

(b) For modified RAs, the response must be initiated within 2½ seconds of being displayed; and,

– For Increase Rate RAs, or for RA reversal, the change in vertical speed must be accomplished with an acceleration of approximately ⅓ g;

– For RAs that weaken or strengthen, the change in vertical speed must be accomplished with an acceleration of approximately ¼g.

3.5. JAA regulations are currently under review in the light of recent (November 2003) changes to the Flight Procedures for Operation of ACAS Equipment established by ICAO[5]. These concern the (new) requirement that in the event of conflict between ATC instructions and ACAS, pilots must follow ACAS.

3.6. Until the publication of revised JARs, operators of ACAS equipped aircraft must review their operating procedures in accordance with the ICAO procedures[5] to ensure that pilots are provided with clear rules stating precisely how they should respond in given circumstances. This guidance should be incorporated in all initial, conversion and recurrent training.

3.7. In essence, these rules are quite straightforward:

(a) Do not take any avoiding action on the sole basis of a TA;

(b) On receipt of an RA:

– respond immediately by following the RA as indicated, unless doing so would jeopardise the safety of the aeroplane;

– follow the RA even if there is a conflict between the RA and an air traffic control (ATC) instruction to manoeuvre;

– do not manoeuvre in the opposite sense to an RA;

– do not manoeuvre laterally;

– as soon as possible, as permitted by flight crew workload, notify the appropriate ATC unit of the RA, including the direction of any deviation from the current air traffic control instruction or clearance;

– promptly comply with any modified RAs;

– limit the alterations of the flight path to the minimum extent necessary to comply with the RAs;

– promptly return to the terms of the ATC instruction or clearance when the conflict is resolved; and,

– notify ATC when returning to the current clearance.

3.8. Further explanation may be necessary to ensure that pilots understand the danger of not following the SOP:

(a) Stall warning, windshear, and Ground Proximity Warning System alerts have precedence over ACAS;

(b) Visually acquired traffic may not be the traffic causing an RA, or it may not be the only traffic to which ACAS is responding. Visual perception of an encounter, particularly the action being taken by the traffic, may be misleading, especially at night. Therefore, the pilot should continue to follow the RA even when he/she believes he has identified the intruder visually;

(c) In the case of an ACAS-ACAS co-ordinated encounter between different aircraft, the RAs complement each other in order to reduce the potential for collision. Manoeuvres, or lack of manoeuvres, that result in vertical rates opposite to the sense of an RA could result in a collision with the threat aircraft;

(d) Separation at CPA is based on the assumption that both pilots follow the indicated manoeuvre; if one pilot does not do so, separation may be less than if that aircraft was not ACAS equipped;

(e) Unless informed by the pilot, ATC does not know when ACAS issues RAs. It is possible for ATC to issue instructions that are unknowingly contrary to ACAS RA indications. Therefore, it is important that ATC be notified when an ATC instruction is not being followed because it conflicts with an RA;

[5] ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I, Flight Procedures Part VIII Chapter 3 Amendment 12.

(f) ACAS equipment updates the position and calculates the trajectory of the threat aircraft once per second; in contrast, the update rate of ATC radar is only once per 4 seconds, or less. Therefore ACAS knowledge of the vertical situation is at least 4 times greater than ATC.

3.9. SOPs should stress that in the event of a level bust that involves an actual risk of collision, the ACAS is the only means to resolve the situation effectively. **It is therefore imperative that pilots follow the RA.**

3.10. ATM procedures in regard to ACAS equipped aircraft and the phraseology to be used for the notification of manoeuvres in response to an RA are contained in the PANS-ATM.[6]

4. ACAS and RVSM

4.1. Interim assessments by the ACAS Programme, since the implementation of RVSM, have not indicated any evidence to suggest that ACAS is generating any major problems within RVSM airspace. The improved height keeping performance of RVSM approved flights is beneficial to ACAS performance.

4.2. Within RVSM airspace, unless there are differing instructions within National AIPs, aircraft should climb/descend in accordance with normal flight profiles except when approaching the cleared flight level.

4.3. ICAO is developing guidance material in order to prevent unnecessary RAs associated with high vertical rates. The guidance will advise pilots that when traffic information is provided by ATC the rate of climb or descent should be less than 1500 ft per min when approaching 1000 ft above or below the cleared flight level.

5. Training

5.1. ACAS should be included in ab-initio and continuation training for civil and military pilots and for ATC controllers.

5.2. JAA TGL11[4] contains valuable guidance on the development of training programmes. However, the current version of this document (October 1998) is under review in the light of the revision to ICAO Pans-OPS (see paragraph 3.3. above).

6. Summary

6.1. ACAS is a last resort system, which operates with very short time thresholds before a potential near mid-air collision. It assesses the situation every second, based on accurate surveillance in range and altitude. For maximum efficiency, when both aircraft are operating ACAS in RA mode, ACAS co-ordinates the RAs. ACAS is extremely effective.

6.2. Pilots must follow all RAs even when there is:

(a) ***an opposite avoiding instruction by the controller***. If the RA is not followed, it can adversely affect safety when the other aircraft responds to a co-ordinated RA;

(b) ***conflict at maximum operating altitude.*** If a climb RA is generated commence a climb, do not descend opposite to the RA. Maximum altitude usually permits a 200 ft min capability. Otherwise, if the aircraft is performance limited the ACAS is usually programmed not to give the relevant warning. Operators should check with equipment manufacturers and brief crews accordingly;

(c) ***traffic information from the controller.*** The slower update rate of the radar display, even with radar data processing system (RDPS) multi-radar data, means that the vertical situation seen by the controller may be inaccurate, particularly when aircraft are rapidly climbing or descending;

(d) ***visual acquisition.*** The wrong aircraft could be identified and the situation may be wrongly assessed.

6.3. It is recognised that workload is often high during an ACAS RA encounter, nonetheless pilots must notify ATC as soon as possible using the standard phraseology (e.g. "[callsign] TCAS CLIMB").

6.4. This information will help the controller in his/her task: "When a controller is informed that a pilot is following an RA, the controller shall not attempt to modify the aircraft flight path until the pilot reports returning to the clearance. He/she shall provide traffic information as appropriate".

6.5. For maximum safety benefit from ACAS, follow RAs promptly and accurately.

7. Examples

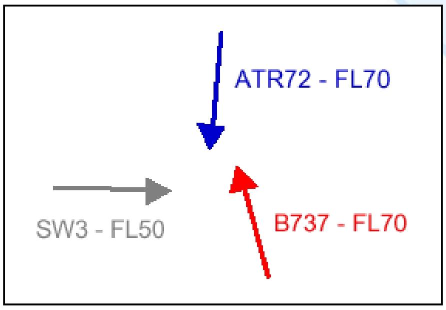
7.1. The examples and information[7] that follow illustrate the operation of ACAS as well as the potential dangers of non-compliance with sound standard operating procedures.

7.2. Examples 1-7 illustrate actual operational encounters. Examples 8 & 9 illustrate the performance of ACAS in common scenarios.

[6] ICAO Doc 4444 – Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-ATM) Chapters 15 and 12 respectively

[7] These examples include material taken from two EUROCONTROL Safety Letters: "ACAS II bulletin – Follow the RA!", and, "Reducing Level Bust".

Example 1: ATC Avoiding Instruction Opposite to RA



Two aircraft level at FL70 are being radar vectored by the approach controller:

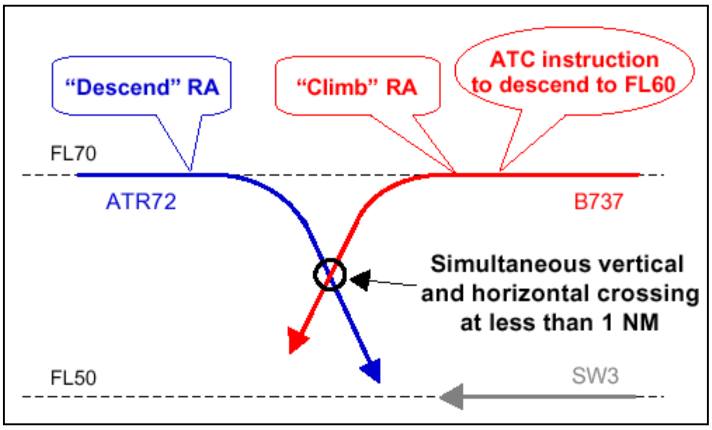
- an ATR72 is heading 185°;
- a B737 is on opposite track heading 345°.

A third aircraft (SW3) level at FL50 is heading east.

All aircraft are in IMC.

Because the controller is occupied with the resolution of another conflict, the B737 is instructed, late, to descend to FL60 when the aircraft are slightly less than 5 NM head on.

Both aircraft are at the same level and converging quickly. The ACAS of each aircraft triggers a co-ordinated RA a few seconds later:



- the ATR72 pilot receives a "Descend" RA that he follows;
- the B737 pilot receives a "Climb" RA that he does not follow. He continues to comply with the ATC instruction.

The ATR72 pilot immediately informs the controller that he has a "Descend" RA using the standard phraseology. However just after, the controller repeats to the B737 the instruction to descend to FL60 for avoiding action.

The B737 pilot, who has reported afterwards that he '*had to avoid ACAS alert*", descends through FL60. This opposite reaction to his "Climb" RA induces an "Increase Descent" RA on-board the ATR72, which leads the pilot to deviate much more than initially required by ACAS. This large vertical deviation induces a new ACAS conflict with the SW3 level at FL50.

If the B737 pilot had responded correctly to his "Climb" RA, the vertical separation between the ATR72 and the B737 would have been 600 ft (i.e. 300 ft vertical deviation for each).

The Air Traffic Controller and ACAS as a "last resort safety net"

When a loss of separation is likely to occur or has occurred, the controller has to:

- *detect the conflict using the available tools (e.g. radar display, Short Term Conflict Alert [STCA]);*
- *assess the situation;*
- *develop a solution in a very short period of time;*
- *communicate this solution to the aircrew as quickly and clearly as possible.*

The detection of the conflict may bae delayed due to tasks with other aircraft under his/her control. Communications with conflicting aircraft may also be delayed due to RTF congestion or misunderstandings between the controller and the pilots.

ACAS automatically detects any risk of collision for the mode C equipped aircraft. When a risk of collision is detected, it calculates the necessary vertical avoidance manoeuvre and communicates the solution directly to the flight crew via the RA display and an aural message attention-getter. It does this in less than one second.

Whenever both aircraft are operating ACAS in TA/RA mode, ACAS co-ordinates the RAs.

In 1996 a near-collision occurred in the holding pattern near a major international airport. The controller was alerted to the loss of separation by the STCA but was obliged to ask each aircraft in turn for its altitude before avoiding instructions could be issued. Both aircraft were in cloud and neither crew saw the other. Neither aircraft was fitted with ACAS. Subsequent analysis revealed that the aircraft came within 100 ft vertically and around ½ a mile horizontally of each other.

Example 2: ATC Avoiding Instruction Opposite to RA

A B737 is level at FL280 flying a north-west route. An A321 is climbing cleared to FL270 and flying a southbound route. Due to a misunderstanding with the controller, the A321 pilot busts his altitude and continues to climb to FL290.

The controller detects the altitude bust and takes corrective actions. He instructs the A321 to descend immediately to FL270 (it is displayed on the radar at FL274) and the B737 to climb to FL290. The B737 pilot initiates the climb manoeuvre but the A321 pilot continues to climb instead of descending back to FL270.

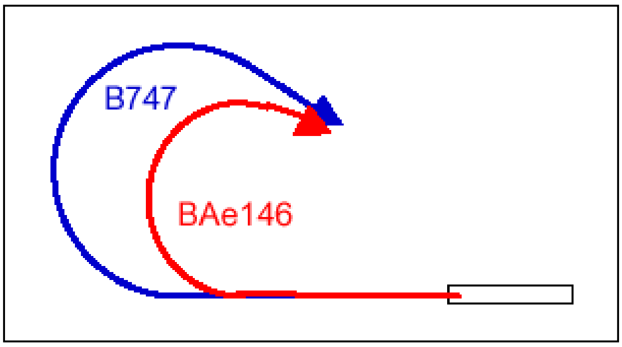
A few seconds later, the ACAS of each aircraft triggers a co-ordinated RA: a “Climb” RA for the A321 (it is now 300 ft above the B737) and a “Descend” RA for the B737.

The B737 pilot follows his RA and starts to descend. However, the A321 pilot eventually complies with the ATC instruction, stops the climb and starts to descend despite his “Climb” RA. In addition, the A321 pilot reported that he preferred to avoid the B737 visually

As a result, both aircraft passed less than 2 NM apart, with only 100 ft vertical separation.

If the A321 pilot had followed the ACAS RA, this dangerous situation would have been avoided.

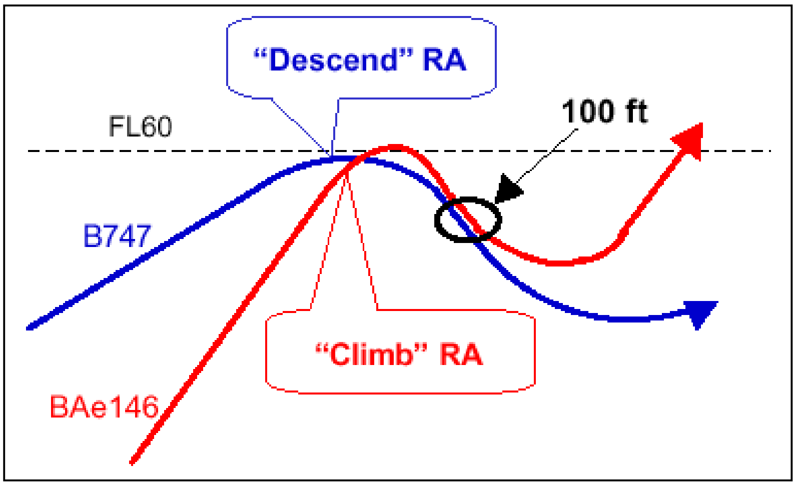
Example 3: Erroneous traffic information and incorrect visual perception



Two aircraft are departing from the same airport, on the westerly runway. The first one is a long-haul B747, which is turning right to heading 150°. The second one is a short-haul BAe146, which is turning to the east, after a steep initial climb. Both aircraft are cleared to FL190.

Due to the good climb performance of the BAe146, the controller gives it an early right turn. This clearance induces a conflict between the BAe146 and the B747.

The controller detects the conflict and provides the B747 with traffic information about the BAe146. The pilot replies “we are passing *6000 feet*”. Then, the controller instructs the BAe146 to “stop climb flight *level 60”*, advising the pilot that a B747 is “1000 ft above climbing”. However, two elements have not been taken into account:



- the pressure is high (QNH 1032), so that the 6000 ft altitude is actually FL54, and FL60 is 6600 ft altitude;
- both aircraft are ACAS equipped so that the ACAS of each aircraft triggers a co-ordinated RA.

The B747 pilot receives a “Descend” RA that he follows: he stops his climb and starts to descend.

The BAe146 pilot has the B747 in visual contact. However, due to the actual B747 flight configuration, the descent manoeuvre is difficult to detect visually (positive pitch). As he is also misled by the erroneous traffic information, he decides to descend visually to avoid the B747 despite his “Climb” RA.

As the B747 is also descending in response to his “Descend” RA, the aircraft continue to get closer.

Because the BAe146 pilot did not follow his “Climb” RA, the B747 deviated by 1200 ft. **However, despite this large vertical deviation, the B747 pilot reported that the two aircraft passed “*very, very, very close*” (i.e. 100 ft and 0.5 NM).**

If the BAe146 pilot had followed the ACAS RA, this dangerous situation would have been avoided.

Example 4: Insufficient Visual Avoiding Manoeuvre

A B747 and a DC10 flying on converging tracks are both cleared to FL370 by mistake. When the controller detects the conflict, he tries to instruct the DC10 to descend to FL350 but uses a mixed callsign.

The B747 pilot wrongly takes the clearance and initiates a descent. At the same time, his ACAS issues a “Climb” RA. However, the pilot decides not to follow the RA because he has the visual acquisition on the DC10 (at the time of the incident, his airline standard operating procedures stated that manoeuvres based on visual acquisition took precedence over RAs) and he continues to descend.

The DC10 pilot who has also the B747 in sight, receives a co-ordinated “Descend” RA that he follows. At the last moment, he stops his descent when he perceives the B747 to be at the same altitude and descending.

At the very last second, the B747 pilot performs a sudden and violent escape manoeuvre, injuring a number of passengers and flight attendants.

***As a result, the B747 passes just beneath the DC10 (by 10 metres reported), with no lateral separation*.**

ACAS Altitude data is better than ATCs

The ATC radar displays are usually provided with data by a Radar Data Processing System (RDPS), whose inputs come from Secondary Surveillance Radars (SSR) with:

- *an update rate of several seconds (from 4 to 10s)*
- *altitude data in 100 ft increments*

Sudden vertical manoeuvres may not be displayed immediately. For instance, the altitudes displayed for a manoeuvring aircraft may lag by as much as 500 ft. In addition, the displayed vertical tendency may be erroneous in some cases.

ACAS interrogates all surrounding transponders every second, making the update 4 to 10 times quicker than SSRs. Mode S equipped aircraft provide ACAS with 25 ft increments making it 4 times more accurate.

Therefore, for aircraft in close proximity, the ACAS knowledge of the vertical situation is much better than the ATC one. It can be considered to be at least 4 times more accurate, and 4 times more up-to-date.

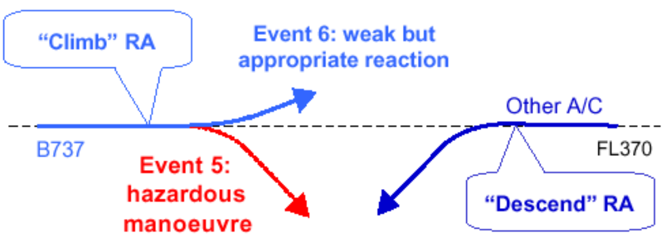
Visual Acquisition - Limitations

- *The visual assessment of traffic can be misleading. At high altitude, it is difficult to assess the range and heading of traffic as well as its relative height. At low altitude, the heavy aircraft attitude at low speed makes it difficult to assess whether it is climbing or descending.*
- *Visual acquisition does not provide any information about the intent of other traffic.*
- *The traffic in visual contact may not be the threat that triggers the RA. A visual manoeuvre relative to the wrong visual traffic may degrade the situation against the real threat.*

Examples 5 & 6: “Climb” RA at the Maximum Certified Flight Level

Two events involving a B737 level at FL370 (i.e. the maximum certified flight level for this specific aircraft type) have been identified where the pilot reaction to the “Climb” RA has been different. In both these events, the B737 was flying towards another aircraft level at the same altitude due to an ATC mistake and the ACAS generated a “Climb” RA.

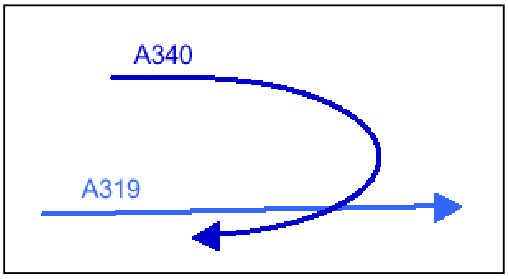
Example 5: the B737 pilot decided not to climb in response to the RA as the aircraft was flying at the maximum certified flight level. However, as he wanted to react to the ACAS alert, he then decided to descend. He did not take into account that the other aircraft would receive a co-ordinated “Descend” RA. As a result, the B737 pilot descended towards the other aircraft, which was correctly descending in accordance with its own RA.



Example 6: the B737 pilot climbed in response to his RA, but as one could expect, he was not able to comply with the normal 1500 fpm vertical rate requested by the RA. He climbed only about 100 ft. However, even this slight climb was beneficial as the other aircraft received a co-ordinated “Descend” RA, which was correctly followed by the pilot. The vertical separation achieved was the vertical deviation of the descending aircraft PLUS the 100 ft achieved by the B737.

In conclusion, DO NOT react contrary to an RA: if there is some doubt of the ability to respond to a “Climb” RA, at least remain level, do not descend.

Example 7: Correct Response to RAs by Both Pilots



An A340 and an A319, which are departing from two different airports, are in contact with different controllers but in the same airspace.

The A340, in contact with the departure controller, is cleared to climb to FL150 with an initial heading 090°. The A340 climbs slowly and is planned to climb above the A319.

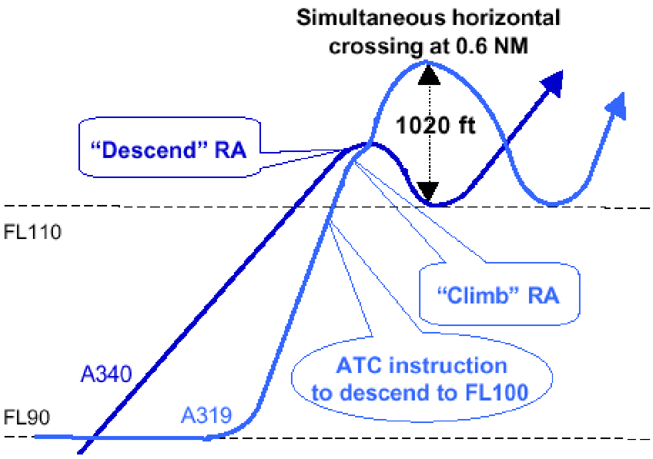
The A319, which is level at FL90 and also heading east, is already in contact with the en-route centre.

When passing through FL100, the A340 is turned to the right by the departure controller. At the same time, the A319 is cleared by mistake by the en-route controller to climb to FL210, which induces a conflict with the A340. The en-route controller detects the conflict and instructs the A319 to stop climb at FL100. The A319 pilot replies that he has already passed FL100 and that he is descending back to FL100.

However, because of the simultaneous horizontal and vertical convergence, the ACAS of each aircraft triggers a co-ordinated RA:

- the A340 receives a "Descend" RA that he follows correctly despite the clearance to climb to FL150
- the A319 receives a "Climb" RA that he also follows correctly even though he has already started his manoeuvre to descend back to FL100

In this event, the correct responses to the RAs by both pilots provide more than the ACAS vertical separation objective.

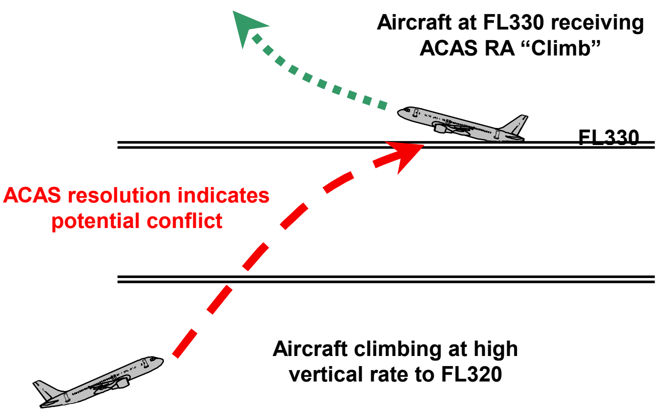


Example 8: ACAS Bump-up.

Induced Deviation from Clearance

An ACAS RA can be issued where an aircraft is climbing, or descending, **with a high vertical rate** to a cleared level that is 1000 ft from an adjacent aircraft. An RA issued in the adjacent aircraft could cause the aircraft to deviate from its cleared flight level. This is sometimes referred to as an "operationally unnecessary" or "nuisance" RA, but it is entirely justified. If the aircraft that is climbing or descending does not successfully level off at its cleared flight level the risk of collision is very real.

There have been many recent altitude busts, where aircraft failed to level off at their cleared flight level. So it is important that pilots follow the RA.



Logic modifications mean that the majority of RAs issued in these situations do not now require a move off level by the level aircraft, or a reversed vertical rate by the climbing/descending aircraft. However, ***occurrences of RAs can be minimised if pilots adjust their rate of climb/descent to 1500 ft per min. when they are approaching an altitude 1000 ft above, or below, their cleared level.***

At a number of airports, departure routes (SIDs) climb under holding stacks or arrival routes. Where possible, Terminal Areas are designed to avoid the types of interaction between departing and arriving traffic that make level bust incidents more hazardous.

Example 9: Knock-on Effects

Concerns are often expressed that RAs could induce conflicts with other aircraft. This is particularly the case where aircraft are "packed" close to each other, for example, in a holding pattern serving a major airport.

The following worst-case scenario demonstrates that in such a situation, the safest procedure is for all aircraft to follow the RA.

Three aircraft are in a holding pattern at FL80, FL90 and FL100, coincidentally all exactly one above the other.

A fourth aircraft (blue line) busts FL110, and mistakenly enters the hold descending to FL100, on top of the aircraft (red line) already occupying that level.

All four aircraft are ACAS equipped (Figure 1).

- The joining aircraft receives a TA as he passes FL112;
- He receives an RA requiring a level-off as he passes FL107;
- The aircraft already at FL100 receives an RA and descends 200ft;
- The aircraft at FL90 receives a TA only.

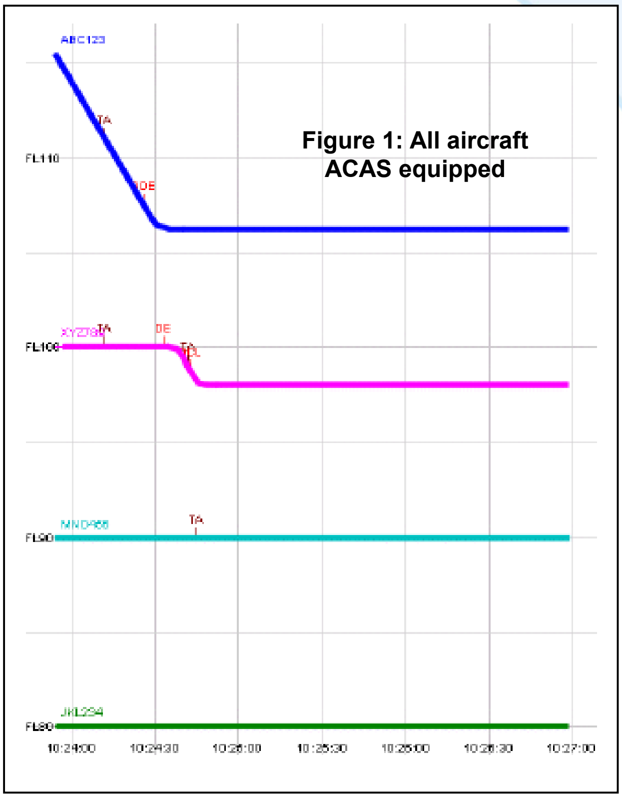


Figure 1: All aircraft ACAS equipped

In this case, separation between the joining aircraft and that at FL100 is lost, but the ACAS safety net prevents a potential mid-air, or near mid-air collision. Only the joining aircraft commits a level bust.

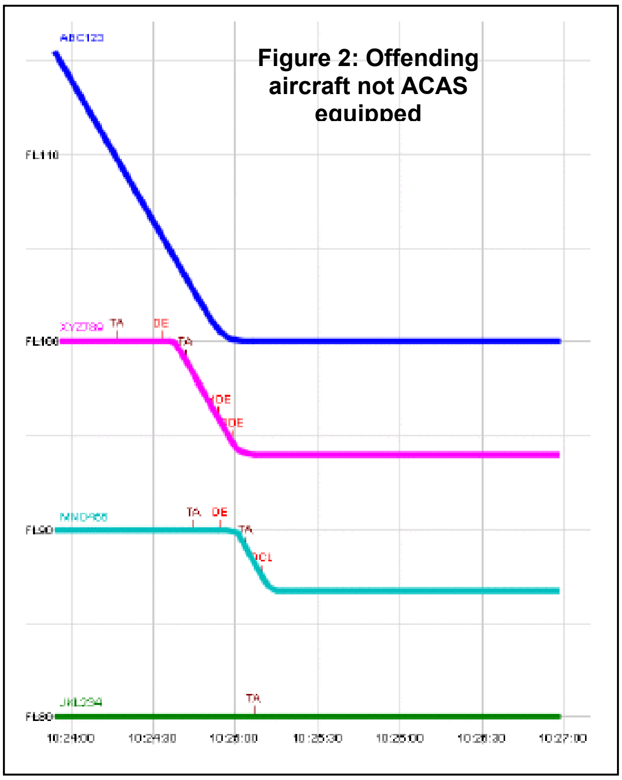


Figure 2: Offending aircraft not ACAS equipped

ACAS can still resolve the situation when the offending aircraft is not ACAS equipped and continues its descent to FL100 (Figure 2).

- Aircraft at FL100 (red line) receives an RA and descends 600 ft;
- This induces an RA in the aircraft below (green line) which descends 300 ft;
- The aircraft at FL80 receives a TA only.

In this case, separation is seriously reduced, but a collision risk will not arise provided all aircraft followed the instructions given by their ACAS equipment promptly and accurately.

In the absence of ACAS, a controller, however skilled, would find it extremely difficult to resolve the conflict before a dangerous situation developed (see the information at the foot of Page 3).

This emphasises the point that in the event of a level bust that involves an actual risk of collision, the ACAS is the only means to resolve the situation effectively.

It is therefore imperative that pilots follow the RA.

8. Resources

Other Level Bust Briefing Notes

8.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

OPS 1 – Standard Operating Procedures;

OPS 3 – Standard Calls;

OPS 4 – Aircraft Technical Equipment.

Access to Resources

8.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from *ICAO*;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from *FSF*;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from *JAA*.

Regulatory References

8.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 10 Volume IV – Surveillance Radar and Collision Avoidance Systems;

ICAO Doc 4444: PANS-ATM, Chapters 12 and 15;

ICAO Doc 8168: PANS-OPS, Volume I – Flight Procedures, Part VIII Chapter 3;

ICAO Doc 7030 Section 16: Use of ACAS;

JAR-OPS 1.398 – Use of Airborne Collision Avoidance System (ACAS);

JAR-OPS 1.652 – Flight and Navigational Equipment & Associated Equipment;

JAR-OPS 1.668 – Airborne Collision Avoidance System.

Training Material & Incident Reports

EUROCONTROL Safety Letter – Airborne Collision Avoidance Systems (ACAS);

EUROCONTROL ACAS II Bulletin: "Follow the RA!";

EUROCONTROL – ACAS Training for Operations in RVSM Environment;

EUROCONTROL – Replay Interface of TCAS Advisories (RITA) – a dynamic graphical tool showing TCAS occurrences;

JAR-OPS TGL-11 – Guidance for Operators on Training Programmes for the use of ACAS;

Report by the Norwegian Air Accident Investigation Bureau into an Airprox between an Airbus A310 and a Boeing 737 at Oslo in February 2002;

UK CAA Flight Operations Department Communication 2/03 – Airprox report 105/02 – TCAS Incident – Level Bust.

Other References

UK CAA ATSIN 15/02 – ACAS Interface with Air Traffic Control;

UK CAA CAP 710 – "On the Level" and associated recommendations;

UK CAA Flight Operations Department Communication 27/03 – ACAS: Action to be Taken Following a Resolution Advisory (RA).

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

OPS 6
Human Factors

1. Introduction

1.1. Human factors identified in level bust incidents (including accidents resulting from level busts) should be used to assess a company's risk exposure and develop corresponding company accident-prevention strategies, or to assess an individual's risk exposure and develop corresponding personal lines of defence.

1.2. Whether involving crew, air traffic control, maintenance, organisational factors or aircraft design, each link of the error chain involves human beings and, therefore, human decisions and behaviour.

2. Statistical Data

2.1. Human error is involved to a greater or lesser extent in all aviation accidents, whether predominately due to operational or technical causes.

3. Human Factors Issues

Standard Operating Procedures (SOPs)

3.1. Following SOPs and normal checklists is an important defence against human error.

3.2. Pilots sometimes deviate intentionally from SOPs; some deviations occur because the procedure that was followed in place of the SOP seemed to be appropriate for the prevailing situation. Other deviations are usually unintentional.

3.3. The following factors are often cited in discussing deviations from SOPs:

(a) Task Saturation;

(b) Inadequate knowledge or failure to understand the rule, procedure or action because of:

– Inadequate training;

– Printed information not easily understood; and/or,

– Perception that a procedure is inappropriate;

(c) Insufficient emphasis on adherence to SOPs during transition training and recurrent training;

(d) Inadequate vigilance (fatigue);

(e) Interruptions (e.g. because of pilot-controller communications);

(f) Distractions (e.g. because of flight deck activities;

(g) Incorrect management of priorities (lack of decision-making model for time-critical situations);

(h) Reduced attention (tunnel vision) in abnormal conditions or high-workload conditions;

(i) Incorrect crew resource management (CRM) techniques (for crew co-ordination, cross-check and backup);

(j) Complacency; and/or,

(k) Overconfidence.

Automation

3.4. Errors in using flight guidance systems (FGSs) and insufficient knowledge of FGS operation have been contributing factors in level bust incidents, including controlled flight into terrain (CFIT) accidents.

3.5. The following are some of the more common errors in using FGSs:

(a) Incorrect altitude entry and failure to confirm the entry on the primary flight display (PFD);

(b) Entering a target altitude that is lower than the final approach intercept altitude during approach;

(c) Inadvertent selection of an incorrect mode;

(d) Failure to verify the selected mode by reference to the flight-mode annunciator (FMA);

(e) Failure to arm a mode (e.g. failure to arm the approach mode) at the correct time;

(f) Inadvertent change of target entry (e.g. changing the target heading instead of entering a new altitude); and/or,

(g) Failure to monitor automation and cross-check parameters with raw data.

3.6. Other frequent causal factors in level busts include:

(a) Incorrect interaction with automation;

(b) Over-reliance on automation; and/or,

(c) Inadequate effective crew co-ordination, cross-check and backup.

Briefing Techniques

3.7. The importance of briefing techniques is often underestimated, although effective briefings enhance crew standardisation and communication.

3.8. Routine and formal repetition of the same information on each flight may be counterproductive; adapting and expanding the briefing by highlighting the special aspects of the procedure to be flown, or the actual weather conditions, will result in more effective briefings;

3.9. In short, the briefing should attract the attention of the pilot not flying (PNF) (pilot monitoring).

3.10. The briefing should help the pilot flying (PF) and the PNF to know the sequence of events and actions, as well as the special threats and circumstances of the procedure.

3.11. An interactive briefing style provides the PF and the PNF with an opportunity to fulfil two important goals of the briefing:

(a) To correct each other; and

(b) To share a common mental image of the procedure.

Crew-ATC Communication

3.12. Effective communication is achieved when our intellectual process for interpreting the information contained in a message accommodates the message being received.

3.13. This process can be summarised as follows:

(a) How do we perceive the message?

(b) How do we reconstruct the information contained in the message?

(c) How do we link the information to an objective or to an expectation?

(d) What amount of bias is introduced in this process?

3.14. CRM highlights the relevance of the context and the expectations in communication.

3.15. The following factors may adversely affect the understanding of communications:

(a) High workload;

(b) Fatigue;

(c) Interruptions;

(d) Distractions; and/or,

(e) Conflicts and pressures.

3.16. The results may include:

(a) Incomplete communication;

(b) Omission of the aircraft callsign or use of an incorrect callsign;

(c) Use of non-standard phraseology; and,

(d) Failure to listen and respond.

3.17. Just as the use of non-standard phraseology can affect the understanding of communications, the insistence on standard phraseology in high-stress situations makes a positive contribution to the elimination of error.

Crew Communication

3.18. Interruptions and distractions on the flight deck break the flow pattern of ongoing activities, such as:

(a) SOPs;

(b) Normal checklists;

(c) Communication (listening, processing, responding);

(d) Monitoring tasks; and,

(e) Problem-solving activities.

3.19. The diverted attention resulting from the interruption or distraction usually causes the flight crew to feel rushed and to be confronted with competing tasks.

3.20. Moreover, when confronted with concurrent task demands, the natural human tendency is to perform one task to the detriment of another.

3.21. Unless mitigated by adequate techniques to set priorities, interruptions and distractions may result in:

(a) Not monitoring the flight path;

(b) Missing or misinterpreting an ATC instruction;

(c) Omitting an action and failing to detect and correct the resulting abnormal condition or configuration; and,

(d) Leaving uncertainties unresolved.

3.22. All these errors have the potential to result in a level bust, perhaps leading to an Airprox, mid-air collision or controlled flight into terrain (as well as other possible undesirable outcomes).

Altimeter Pressure Setting Error

3.23. An incorrect altimeter pressure setting is often the result of one or more of the following factors:

(a) High workload;

(b) Incorrect pilot-system interface;

(c) Incorrect pilot-controller communication;

(d) Deviation from normal task-sharing;

(e) Interruptions and distractions; and/or,

(f) Insufficient backup between crewmembers.

3.24. Adherence to the defined task-sharing (for normal conditions and abnormal conditions) and use of normal checklists and SOPs are the most effective lines of defence against altimeter-setting errors.

4. Summary

4.1. Addressing human factors in level bust incidents must include:

(a) Defined company safety culture;

(b) Defined company safety policies;

(c) Company accident prevention strategies;

(d) SOPs;

(e) CRM practices; and,

(f) Personal lines of defence.

5. Resources

Other Level Bust Briefing Notes

5.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

OPS 1 – Standard Operating Procedures;

OPS 2 – Altimeter Setting Procedures;

OPS 3 – Standard Calls;

OPS 4 – Aircraft Technical Equipment;

OPS 5 – Airborne Collision Avoidance Systems;

ATM 2 – Reducing Level Busts.

Access to Resources

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ICAO – Annex 6 – Operation of Aircraft, Part I – International Commercial Air transport – Aeroplanes;

ICAO Doc. 8168 – Procedures for Air Navigation services. Aircraft Operations (PANS-OPS). Volume 1: Flight Procedures;

ICAO Doc. 9376 – Preparation of an Operations Manual;

ICAO Doc. 9683 – Human Factors Manual;

JAR-OPS 1.943, 1.945, 1.955 and 1.965 and associated ACJs and IEMs concerning Crew Resource Management;

JAR-OPS 1.1045 and associated Appendix 1 – Operations Manuals – structure and contents.

Training Material

FSF Approach and Landing Accident Reduction (ALAR) Toolkit Briefing Note 2.1 – Human Factors;

FSF Human Factors and Aviation Medecine 5/93 – Hurry-up Syndrome

Training Material – Posters

Level Bust Prevention posters produced by the UK CAA:

2 Many Things

Low QNH – High Risk

No Rush – No Mistake

Wun Wun Zero.

Incident Reports

FSF Accident Prevention 4/98 – Boeing 737 Pilot Flying Selects Incorrect Altitude in Holding Pattern

Norwegian Air Accident Investigation Branch Report 17/2002 – Violation of Separation Minima due to Level Bust;

UK CAA Flight Operations Department Communication – 12/2003 – Airprox Report 105/02 – TCAS Incident – Level Bust.

Other References

FSF Digest 6/93 – Common Errors behind Altitude Deviation;

Proceedings of the Royal Aeronautical Society – Human errors that contribute to Altitude Deviations;

UK CAA CAP 710 – On the Level & Recommendations;

UK CAA CAP719: Fundamental Human Factor Concepts.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

OPS 7
Safety Reporting: Operators

1. Introduction

1.1. The reporting of aviation safety occurrences is important for several reasons:

(a) It allows the causes of occurrences to be investigated;

(b) Based on the findings of the investigation, action may be taken to prevent similar occurrences;

(c) Subsequent occurrence reporting will indicate whether the corrective action was successful;

(d) Important safety information uncovered as a result may be shared with other operators.

1.2. There are three main categories of safety occurrences:

(a) Accidents and Serious Incidents;

(b) Incidents;

(c) Other Safety Occurrences.

1.3. The basic requirements for the reporting of all types of safety occurrence are laid down by ICAO. For aircraft operators, these are amplified by JAA and by national authorities[1]. Similar regulations are laid down by JAA for manufacturers and by EUROCONTROL for air navigation service providers (ANSPs).

1.4. Reporting of safety occurrences of all categories is important because it allows an accurate picture of the safety situation to be built up so that timely and effective accident prevention measures can be taken. It is also a valuable tool to judge the effectiveness of such measures.

Accidents and Serious Incidents

1.5. Accidents and serious incidents are defined by ICAO[2] and must be reported. The only difference between an accident and a serious incident is in its result: a serious incident may be regarded as an accident that almost happened.

Incidents

1.6. Incidents are also defined by ICAO[2]. They are occurrences which fall short of the definition of Accident or Serious Incident, but which nevertheless affect, or could affect, the safety of the aircraft. They should be reported under a national mandatory incident reporting system[3].

1.7. Examples of incidents include level bust, airborne collision avoidance system (ACAS) resolution advisory (RA) (except for nuisance warnings) and near mid-air collision (AIRPROX).

1.8. In practice, not all such incidents are reported, either because the pilot or the operator does not realise that they are reportable incidents, or because the pilot fears some form of punishment.

1.9. Incidents have occurred where two aircraft operating within the same geographic area have been issued with the same transponder code. Such incidents have obvious relevance to the level bust issue and should always be reported and investigated.

1.10. Air traffic incidents and ACAS RAs should also be reported separately under the relevant incident reporting schemes.

Safety Occurrences

1.11. Some safety occurrences are not sufficiently serious to require reporting under a mandatory incident reporting system, but are nevertheless important. These lesser safety occurrences should be reported under a voluntary incident reporting system.[4]

[1] See Section 7 of this briefing note for details of ICAO and JAA regulations.

[2] ICAO Annex 13 Chapter 1.

[3] ICAO Annex 13 Chapter 8 paragraph 8.1.

[4] ICAO Annex 13 Chapter 8 paragraph 8.2.

2. *Voluntary Incident Reporting System*

2.1. The voluntary incident reporting system should be used for reporting all types of safety occurrence, whether or not there is a mandatory requirement to report them to the national aviation authority.

2.2. The total body of safety occurrences may be visualised as an iceberg where only the accidents, serious incidents, and some other reportable incidents are visible above the water line (See Figure 1).

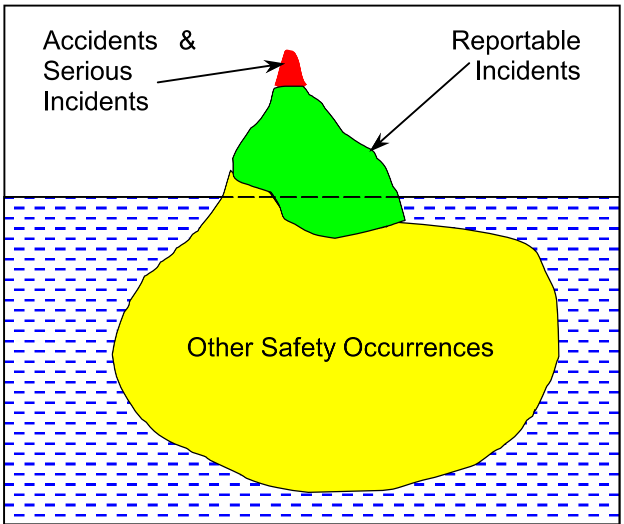

Figure 1 – The Incident Iceberg

2.3. Out of sight lies a large body of unreported incidents and safety occurrences of greater or lesser seriousness, many of which would be made visible by an effective voluntary safety incident reporting system.

2.4. There is obvious merit in reporting to the company system the following classes of safety occurrence:

(a) When a level bust almost occurred, especially when the aircraft actually deviated from its cleared altitude;

(b) When the ACAS operated in an unsatisfactory manner, including nuisance warnings;

(c) When similar callsigns could have given rise to confusion.

2.5. All employees – not just flight crew but cabin crew, operations staff, engineers, etc. – should be encouraged to report safety occurrences of which they become aware.

2.6. In the first case, occurrences are usually reported to the flight safety department, which reviews the reports and takes appropriate formal reporting action if necessary. The flight safety department may also decide to instigate an investigation if appropriate.

2.7. To be effective, a voluntary incident reporting system must have the full support of airline employees. This implies that:

(a) Employees must not be punished on the basis of evidence contained in voluntary reports where occurrences would not otherwise have come to light;

(b) The confidentiality of reporters must be protected;

(c) Reporters must be confident that the incident reporting scheme is worthwhile and that their reports are acted on.

2.8. ICAO Annex 13 Chapter 3 Paragraph 3.1 states a fundamental principle that should guide all occurrence reporting:

> *The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.*

2.9. Usually, a computer database is the most effective means of managing a safety incident reporting system.

2.10. Schemes exist for the sharing of the information contained in such databases without revealing the identity of the reporter or the operator.

3. *Just Reporting Policy*

3.1. Full and free occurrence reporting is fundamental to the establishment of a strong safety culture within an airline. For this to exist, employees must be confident that they will be treated fairly following an occurrence report.

3.2. The person reporting an occurrence should be protected from punishment where a genuine error was made that would not otherwise have been discovered, to the extent that this is possible within the law and national aviation regulations.

3.3. The confidentiality of reporters must also be protected so that they are not exposed to humiliation as a result of their reports being made public.

3.4. Operators should bear in mind that operational errors may occur for a number of reasons which are as much the responsibility of the operations or training departments as the reporter himself. It is important that they should learn of these system failures and correct them to prevent future unsafe situations. The following are typical examples:

(a) The structure or wording of operating procedures may be unsatisfactory;

(b) Training methods may be inadequate;

(c) A culture may exist within the airline where good procedures and sound training are often disregarded;

(d) The cockpit layout may make a mistake more likely.

3.5. The Company Reporting Policy should be prepared in consultation with representatives of the employees. It should be endorsed by the Chief Executive, inserted in the company Operations Manual and brought to the attention of all employees.

3.6. A draft statement contains the essential elements of a just reporting policy is shown below.

Draft Statement of Just Reporting Policy

The safety of operations is a paramount responsibility of airline management and personnel and is in the interests of air transport users, the company and its employees; it is therefore important that any event that affects air safety is reported fully, freely and in a timely manner.

The purpose for encouraging any person concerned to report any event or incident that might affect safety is to establish facts and cause and thereby prevent further occurrence; it is not to apportion blame or liability. The identity of any person making such a report will not be disclosed unless required to do so by the company's national authority or by law.

Normally, disciplinary action will be contemplated only in those instances in which the company considers that the employee concerned has acted recklessly, or omitted to take action, in a way that is not in keeping with training, responsibilities and/or experience.

In considering the event or incident, the company will take favourable account of the fact that an employee has complied with his/her responsibilities to co-operate and to report the circumstances of the event/incident.

3.7. Managerial staff at all levels must actively support the company reporting policy and must be seen to do so.

3.8. At first, employees may be suspicious and it may take some time to build up a sufficient level of trust so that they feel confident that the company will honour the spirit of its policy statement.

3.9. A single case of apparent injustice can undermine or even destroy the confidence of employees. It is therefore recommended that when any form of discipline is contemplated, the matter should be discussed with the employees' representatives (pilot's union, etc.).

3.10. Guidance on the establishment and operation of a safety management system is obtainable from many civil aviation authorities, including those listed in *Section 8 – Resources*.

4. Flight Data Analysis[5]

4.1. As with other classes of occurrence, the analysis of data from flight data recorders can be a valuable source of information:

(a) To assist in the investigation of level bust incidents; and,

(b) To identify unreported level busts.

4.2. One method[6] of operation compares the altitude set in the Altitude Selector with the actual altitude indicated on the altimeter: this figure should always decrease as the aircraft closes on its cleared altitude. If the difference increases for more than 15 seconds *and* becomes greater than 300 feet, a level bust event is activated.

4.3. Another method uses the flight recorder to detect all occurrences of a return to a just vacated flight level.

4.4. These procedures are not perfect and do not capture all cases; however, they do indicate the most common situations in which level busts occur and so, with the aid of confidential pilot debriefing, improve understanding of the level bust issue.

4.5. A successful flight data analysis scheme relies heavily on the support of the pilots and should not be undertaken without full consultation and the agreement of representatives of the pilot's union.

4.6. UK CAA CAP 739 contains useful advice on the implementation of a flight data analysis scheme.

[5] See Section 7 of this briefing note for regulations in regard to flight data analysis.
[6] Air France Flight Data Monitoring Altitude Deviation Programme

5. Incident Databases

5.1. A number of different proprietary software packages have been developed specifically to handle airline safety incident databases. Some of these are listed at the end of these notes.

5.2. Operators should consider carefully the features offered by each package before making a choice. The ideal system would contain most of the following features:

(a) Easy to use;

(b) Accessible from all departments of the company at any location via company network or intranet;

(c) More than one person may use the system at the same time;

(d) Reports can be filed from remote locations;

(e) Automatic data entry by e-mail or Internet form;

(f) Security system:

– protects unauthorised access;

– protects confidentiality of report filer;

– multi-tiered, allowing limited access according to security clearance;

– prevents amendment or deletion of entries;

– quarantines data following accident or serious incident;

(g) Automatic response to report filer:

– acknowledges receipt of report;

– advises progress of investigation etc.;

(h) Able to record related data of different types, for example, structured report forms, free text notes and photographs;

(i) Powerful analysis features to identified similar or related events.

(j) Compatible with information exchange systems;

(k) Report writing includes:

– extraction of data to word-processor package;

– ability to select specific data for report automatically;

– drawing of charts or graphs;

– extraction of statistics to standard software packages (eg Excel).

(l) Incident Database Software

5.3. The following incident software packages listed in alphabetical order are currently available. Web-site addresses or contact details are shown in each case.

(a) Aeronautical Events Reports Organizer (AERO)

www.aerocan.com

(b) Airbus Incident Reporting System (AIRS) for human factors event reporting

jean-jacques.speyer@airbus.com

(c) AIRSAFE

kathryn.crispin@sabre.com

(d) Aviation Quality Database (AQD)

www.superstructure.co.nz

(e) AVSiS

www.avsoft.co.uk

(f) British Airways Safety Information System (BASIS)

www.winbasis.com

(g) INDICATE Safety Program

www.atsb.gov.au

6. Sharing Information

6.1. Schemes exist and are under development for the sharing of information between operators. These schemes are important because they allow:

(a) the true dimension of a potential safety issue to become apparent;

(b) operators to learn that their experiences are not unique – that others have similar experiences;

(c) operators to learn from the successful preventive measures taken by others – and avoid wasting time on unsuccessful measures;

(d) the effectiveness of national or regional safety measures to be assessed.

6.2. The Global Analysis and Information Network (GAIN)[7] is an industry led initiative that promotes and facilitates the voluntary collection and sharing of safety information by and among users in the international aviation community to improve safety.

6.3. GAIN is still under development. However, the Safety Trend Evaluation Analysis & Data Exchange System (STEADES)[8] established by IATA is currently in operation and offers a practical and economical way of sharing information with other operators. STEADES also provides a trend analysis service to participants.

6.4. Sharing of information with air traffic services should also be encouraged as it allows operators and controllers to gain better understanding of the particular problems each experiences.

6.5. In the case of specific air traffic incidents, discussion between operators and the relevant air traffic control service is likely to lead to the best preventative measures being developed.

7. Regulation

7.1. *ICAO Annex 13* deals mostly with the reporting and investigation of accidents and serious incidents, but Chapter 8 concentrates on accident prevention measures. In particular, it:

(a) requires states to establish mandatory incident reporting systems to facilitate the collection of information on actual or potential safety deficiencies;

(b) recommends that states should establish a voluntary incident reporting system to facilitate the collection of information that may not be captured by a mandatory incident reporting system; and,

(c) makes important recommendations concerning the use of incident databases, the analysis of data and the exchange of information with other states.

7.2. *ICAO Annex 6 Part 1 Section 3.2* requires operators to establish and maintain an accident prevention and flight safety programme. Regulations in respect of the establishment and maintenance of flight data analysis programmes are also contained in this section.

7.3. Operators should refer to national legislation to determine how their national authorities have interpreted ICAO Annexes 13 and 6. This is especially important in states that have not yet adopted JAR-OPS 1.

7.4. *JAR-OPS 1.037* requires operators to establish accident prevention and flight safety programmes. These must include occurrence reporting schemes, together with machinery to evaluate information revealed by these schemes, propose remedial action and monitor the effectiveness of such action.

7.5. *ACJ OPS 1.037(a)(2)* summarises briefly the characteristics of an occurrence reporting scheme.

7.6. *JAR-OPS 1.037* stresses the need to protect the identity of the reporter and that it is not the function of the flight safety programme to apportion blame.

7.7. JAR-OPS 1.037 is in the course of revision to require flight data monitoring programmes to be established in accordance with ICAO Annex 6. See *NPA OPS-35*.

7.8. *JAR-OPS 1.085(b)* specifies the responsibilities of crewmembers for reporting safety incidents while *JAR-OPS 1.420* details operators' responsibilities for occurrence reporting.

7.9. *The European Aviation Safety Agency (EASA)* is expected to adopt Joint Aviation Authority Requirements and in due course propose regulation that will be binding throughout the European Union.

8. Resources

Other Level Bust Briefing Notes

8.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

ATM 3 – Safety Reporting: Air Traffic Management.

[7] GAIN is an industry led initiative that promotes and facilitates the voluntary collection and sharing of safety information by and among users in the international aviation community to improve safety;

[8] STEADES is the only global safety event database providing analysis of events, with the goal of reducing accident potential and, therefore, costs. It is based on an open, non-punitive, reporting system which is compatible with other reporting systems. STEADES will form an essential part of any Safety Management System.

Access to Resources

8.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory Resources

8.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 6 – Operation of Aircraft – Part I Chapter 3 Section 3.2 – Accident Prevention and Flight Safety Programme;

ICAO Annex 13 – Accident & Incident Reporting;

ICAO Doc 9156 – Accident/Incident Reporting Manual;

ICAO Doc 9422 – Accident Prevention Manual;

JAR-OPS 1.037 – Accident Prevention Programme plus associated IEM & ACJ;

JAR-OPS 1.085(b) – Incident Reporting;

JAR-OPS 1.420 – Occurrence Reporting;

JAA NPA OPS-35.

Information on Safety Management Systems

Australian Civil Aviation Safety Authority;

Canadian Civil Aviation Authority;

UK Civil Aviation Authority;

US Federal Aviation Authority.

Incident Reports

NASA ASRS Database Report Set – 50 Altitude deviations.

Other Resources

Air France Flight Data Monitoring Altitude Deviation Programme;

EUROCONTROL Second Level Bust Workshop:

Analysis of the Risks of Level Bust;

Level Bust: An Empirical Approach;

NASA: Murphi Busts an Altitude;

UK Airprox Board Report: 2001/2;

UK Airprox Board Report: 2002/1;

UK CAA CAP 712 – Safety Management Systems;

UK CAA CAP 382 – Mandatory Occurrence Reporting Scheme;

UK CAA CAP 739 – Flight Data Monitoring.

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ATM 1

Understanding the Causes of Level Busts

1. Introduction

1.1. Most level busts result because the pilot flies the aircraft through the cleared level (either above or below), or levels the aircraft before the cleared level is reached, or deviates from the cleared level.

1.2. An understanding of the problems faced by pilots will help the controller to anticipate situations where a level bust is possible. This may permit the controller to take action to avoid such situations, or to detect them at an early stage before a dangerous situation develops.

1.3. In an ideal world, pilots and controllers would learn about each other's problems from practical experience. Pilots would visit control towers and air traffic control centres; controllers would fly on the flight deck on commercial flights; each would train in each other's simulators. In reality, the opportunity for cross-training is extremely limited; nevertheless, it should be encouraged where possible.

2. Safety Management

2.1. A sound safety management system within the air traffic control organisation is at the heart of accident and incident prevention. Such a system will identify and control risks that may lead to an aircraft accident and will provide solutions, within the more general framework of national and international regulations, appropriate to the ATM operations at specific locations.

2.2. The use of safety management systems by air navigation service providers (ANSPs) is covered in detail by EUROCONTROL regulations, policy statements and related guidance material.[1]

[1] ESARR 3: Use of Safety Management Systems by Air Navigation Service Providers; EATMP Safety Policy document; EATMP Safety Management Implementation Plan; related guidance material.

3. ATC Appreciation of Flightdeck Workload

3.1. Pilots have many tasks to perform; these are normally shared, for example:

(a) The pilot flying (PF) is responsible for controlling the flight path of the aircraft (steering, climbing, levelling, descending) and for managing the engines, by supervising operation of automatic flight systems or by hand-flying the aircraft;

(b) The pilot not flying (PNF) (pilot monitoring) is responsible for monitoring tasks and for assisting the PF. His duties include actioning standard operating procedures (SOPs); managing flight instrumentation when the PF is hand-flying; monitoring systems and aircraft configuration; and, cross-checking the PF to provide back-up as required.

3.2. At all times, one pilot is responsible for operation of the radios, although both pilots normally listen to calls directed to them when other duties permit.

3.3. In addition to operational messages from air traffic control (ATC), the pilots have to make administrative calls to handling agents, airline operations, etc., and listen to voice weather broadcasts and the automated terminal information service (ATIS).

3.4. Periods of very high workload include:

(a) Engine start, taxi, take-off and initial climb, standard instrument departure (SID);

(b) Descent, approach and landing;

(c) Abnormal situations such as equipment malfunction or extreme weather; and,

(d) Emergency situations.

3.5. Multiple frequency changes are often given during high workload periods following takeoff and during the SID. This can cause confusion and distraction from important monitoring tasks.

3.6. Controllers may not be able to avoid passing or revising clearances during periods of high workload. However, by understanding when these occur, by passing clearances as early as possible and by carefully monitoring feedback, they can reduce the possibility of error. Further improvements may be possible by taking account of likely flightdeck workload when designing or revising ATC procedures.

3.7. Climbing through a previously restricted level, and particularly through the First Stop Altitude (FSA), has been identified as a causal factor for level busts. If a new clearance is issued relating to levels, the pilot may assume that the previous restriction no longer applies[2]. To prevent this misunderstanding, the level restriction must be repeated. (e.g. an aircraft on a SID has a height restriction of 3,000 feet until passing waypoint ABC. If the controller wishes to clear the aircraft to FL240 after ABC, the height restriction at ABC should be repeated).

4. Communication

4.1. Break-down in pilot-controller communication is a major cause of level busts.

4.2. Some circumstances make communication break-down more likely. These fall into two classes:

(a) Circumstances associated with the transmission of the message by the controller; and,

(b) Circumstances associated with the reception of the message by the pilots and their subsequent action.

5. Circumstances associated with the transmission of the message by the controller

5.1. A message from the controller may be misunderstood, or a pilot may take a clearance intended for another aircraft. This is especially likely in the following circumstances:

(a) Frequency congestion (perhaps leading to the controller speaking too quickly);

(b) Long clearances, containing several pieces of information that may be confused (e.g. flight level [FL], speed, or heading);

(c) Blocked or simultaneous transmissions;

(d) Late clearances (leaving insufficient time for pilots to re-brief to take account of the changes);

(e) Language difficulties (including the use of colloquial[3] expressions); and/or,

(f) Non-standard phraseology, including abbreviation of callsigns and messages.

6. Circumstances associated with the reception of the message by the pilots

6.1. The pilots may miss or incorrectly interpret a message from the controller due to circumstances on board the aircraft. This is most likely in the following circumstances:

(a) High workload (especially during departure or arrival, or following equipment malfunction);

(b) Fatigue (pilot schedules may consist of a large number of short sectors repeated for several days or very long flights crossing a large number of time-zones);

(c) Distractions or interruptions (from other crew-members or from company messages on a different frequency); and/or,

(d) Language difficulties (the pilot's command of English may be limited).

6.2. It has been found that confusion sometimes arises when pilots are cleared to certain flight levels or altitudes, especially FL100, which may be interpreted as FL110, or vice versa (or 10,000 feet may be interpreted as 11,000 feet).

6.3. The controller cannot know what is happening on the flight deck; nevertheless the following defensive measures by the controller will reduce the likelihood of error:

(a) Always use the full company callsign and request confirmation of full callsign if the pilot abbreviates the callsign;

(b) Give clearances, including re-clearances, in good time, if possible anticipating periods of high pilot workload;

(c) Where possible, avoid late changes to a clearance especially where the change necessitates lengthy re-briefing by pilots (e.g. change of take-off runway, change of standard

[2] ICAO is aware of this potential source of error and confirms that a level restriction *will need to be repeated* in order to continue to be in effect after a new clearance related to levels has been issued. This issue will be addressed in an amendment proposal to PANS-ATM which is currently being prepared.

[3] Colloquial language is the every day informal language used by native speakers.

instrument departure [SID], change of landing runway);

(d) Avoid rapid speech when transmitting clearances;

(e) Break down lengthy clearances into chunks, preferably avoiding transmitting elements that could be confused (e.g. flight level, speed, or heading) in the same chunk;

(f) Precede each number in a clearance by the corresponding flight parameter (flight level, heading, airspeed [e.g. “descend to flight level two four zero” instead of “descend to two four zero”])[4];

(g) Take particular care when issuing a clearance to level at flight levels or altitudes that are often confused (e.g. FL100 or FL110)[3];

(h) Avoid colloquial language, especially when the pilots are not native English speakers;

(i) Always use standard phraseology;

(j) Insist on readback; listen carefully to readback; always correct errors; and, insist on correct readback following an error for as many times as is necessary to ensure that the correct clearance has been understood.

6.4. For a detailed discussion of communication problems see Briefing Note GEN 2 – Pilot-Controller Communications.

7. Altimeter Pressure Setting

7.1. Altimeter pressure setting presents several possibilities for error, for example:

(a) A pressure setting in hectopascals (hPa) may be confused with a setting in inches of mercury (in.Hg) (e.g. 993 hPa interpreted as 2993 in.Hg);

(b) The pilot may set the incorrect pressure setting (standard, QNH or QFE) resulting in:

– A clearance to climb to a flight level being understood as a clearance to climb to an altitude, (or a clearance to descend to an altitude being interpreted as a clearance to a flight level);

– An altitude (expressed with reference to QNH) being interpreted as a height above touchdown (expressed with reference to QFE);

(c) The pilot may change pressure setting too soon or too late due to a mistaken assumption of the height of the transition altitude (TA) or transition level (TL).[5]

(d) A flight level or altitude expressed in metres may be interpreted as a flight level or altitude expressed in feet, or vice versa.

7.2. The controller can reduce the likelihood of error by paying close attention to use of standard phraseology and by insisting on the correct readback procedure.

7.3. Standard phraseology is especially important when:

(a) Passing a clearance to pilots whose familiarity with the English language is limited;

(b) Specifying the altitude reference when this changes (e.g. “descend to 3,000 feet QNH” or “set QNH 993 hPa and descend to 3,000 feet”);

(c) Passing the pressure setting to the pilot of a North American aircraft. In the USA and Canada, pressure settings are always expressed in in.Hg.; the pressure setting reference should therefore be stressed (e.g. “set QNH 993 hPa,” not, “set 993”);

(d) Passing an altitude or flight level clearance to a pilot accustomed to use metres as altitude reference. When passing a new altitude or level clearance the altitude reference should be stressed.

7.4. Pilots from the USA and Canada are accustomed to a standard TA of 18,000 feet. There is therefore an enhanced risk of error when clearing them to a flight level below 18,000 feet. This risk may be reduced by repeating the clearance (e.g. descend to flight level one two zero I say again flight level one two zero).

8. Low Temperature Operation

8.1. In a standard atmosphere, the indicated QNH altitude is the true altitude.

[4] Within UK several non-standard practices are followed, in particular the word ‘to’ is omitted from messages relating to flight levels and expressions such as FL100 are spoken as ‘flight level wun hundred’. See GEN2, Section 7.

[5] Within UK, it is standard practice to set QNH on altimeters as soon as clearance to an altitude is received, and to set standard pressure setting as soon as clearance to a flight level is received. Similar practices are followed by operators elsewhere.

8.2. Whenever, the temperature deviates significantly from the standard temperature, the indicated altitude deviates from the true altitude, as follows:

(a) At extremely *high* temperatures, the true altitude is *higher* than the indicated altitude; and,

(b) At extremely *low* temperatures, the true altitude is *lower* than the indicated altitude, resulting in reduced terrain clearance.

8.3. If relevant, controllers must take care not to allocate the lowest altitude in extremely cold conditions.

9. Airborne Collision Avoidance Systems

9.1. Airborne collision avoidance systems (ACAS) are designed to improve safety by acting as a "last resort" method of preventing mid-air collisions. This is achieved by the ACAS requiring pilots to manoeuvre in the vertical plane when the equipment detects an imminent risk of collision.

9.2. ACAS issues two types of warning of potential collision:

(a) A traffic advisory (TA) is issued 20 to 48 seconds before the closest point of approach (CPA) to warn the pilots that a resolution advisory (RA) may follow and to assist in a visual search for the traffic;

(b) An RA is issued 15 to 35 second before CPA to warn the pilots that a high collision risk exists unless the indicated avoiding action is followed.

9.3. Whenever two aircraft are operating ACAS in RA mode, ACAS co-ordinates the RAs so that avoiding action is complementary in order to reduce the potential for collision.

9.4. Manoeuvres, or lack of manoeuvres, that result in vertical rates opposite to the sense of an RA could result in a collision with the threat aircraft.

9.5. Separation is based on the assumption that both pilots follow the indicated manoeuvre; if one pilot does not do so, separation may be less than if that aircraft was not ACAS equipped.

9.6. The update rate of the radar display, even with radar data processing system (RDPS) multi-radar data, is slower than the ACAS update rate. A change in the vertical situation seen by the controller may be delayed, particularly when aircraft are rapidly climbing or descending.

9.7. ICAO[6] gives clear and unequivocal guidance to pilots on the use of ACAS. This may be summarised as follows:

(a) Do not take any avoiding action on the sole basis of a TA;

(b) On receipt of an RA:

- respond immediately by following the RA as indicated, unless doing so would jeopardise the safety of the aeroplane;
- follow the RA even if there is a conflict between the RA and an air traffic control (ATC) instruction to manoeuvre;
- do not manoeuvre in the opposite sense to an RA;
- as soon as possible, as permitted by flight crew workload, notify the appropriate ATC unit of the RA, including the direction of any deviation from the current air traffic control instruction or clearance;
- promptly comply with any modified RAs;
- limit the alterations of the flight path to the minimum extent necessary to comply with the RAs;
- promptly return to the terms of the ATC instruction or clearance when the conflict is resolved; and,
- notify ATC when returning to the current clearance.

9.8. Where a collision risk exists, ACAS provides the most effective means of collision avoidance.

9.9. When a controller is informed that a pilot is following an RA, he should not attempt to modify the aircraft flight path until the pilot reports returning to the clearance. He should provide traffic information as appropriate.

9.10. Automatic indication to the controller that a pilot has received an RA is expected to be introduced in the future.

10. ATC Procedure Design[7]

10.1. The design of instrument procedures (especially standard instrument departures [SIDs]) and their presentation in route manuals is a potential source of pilot error.

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[6] ICAO Procedures for Air Navigation Services – Aircraft Operations, Volume I – Flight Procedures (PANS-OPS, Doc 8168), Part VIII Chapter 3.

[7] See also Briefing Note ATM 4 – Airspace & Procedure Design

10.2. Route manuals are commercially produced documents that interpret the instructions contained in national aeronautical information publications (AIPs), either on paper or electronically. Different aircraft operators do not all use the same route manual.

10.3. The following are examples of situations where errors sometimes occur:

(a) The procedure is excessively complex (this may cause confusion or necessitate frequent reference back to the procedure plate); or,

(b) Alternative procedures for different runways contain different vertical clearance limits (a particular problem in the case of late runway change); or,

(c) The vertical clearance limit may be expressed as a flight level (changing pressure setting may be overlooked when workload is high); or,

(d) The presentation of the procedure in the route manual may be unsatisfactory (e.g. too much information displayed on an SID plate making it hard to spot vital information amongst other detail).

10.4. Possible defensive action includes the following:

(a) Analysis of the procedure with a view to identifying and removing any cause of possible confusion or error.

(b) Review of the presentation to ensure that it represents clearly and unambiguously the intention of the procedure. It may happen that the presentation of the procedure in one route manual causes problems whilst another does not; this can only be discovered by investigating the incident in co-operation with the aircraft operator;

(c) Reinforcing the element of the procedure that gives rise to confusion or error by additional verbal instructions.

11. Summary

11.1. ANSPs and Controllers can make a positive contribution to reducing level busts by:

(a) Reporting level bust incidents and potential incidents;

(b) Analysing incident reports to identify high-risk situations;

(c) Where possible, eliminating high-risk situations at source (e.g. revising procedure design);

(d) Understanding the situations that make level busts more likely;

(e) Adhering strictly to standard phraseology in all communications;

(f) Avoiding giving multiple clearances where possible;

(g) Where possible, reducing pilot distraction during high workload periods by timely transmission of messages and clearances;

(h) Insisting on standard readback procedure;

(i) Paying particular attention to communications with aircraft whose callsigns are similar to others on, or soon expected to be on the same RTF frequency;

(j) When a pilot is following an ACAS RA, the controller should cease giving instructions until the pilot informs her/him that she/he is resuming his clearance.

12. Resources

Other Level Bust Briefing Notes

12.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 2 – Pilot-Controller Communications;

GEN 3 – Callsign Confusion;

ATM 3 – Safety Reporting: ATM;

ATM 4 – Airspace & Procedure Design;

OPS 1 – Standard Operating Procedures;

OPS 2 – Altimeter Setting Procedures;

OPS 5 – Airborne Collision Avoidance Systems;

OPS 6 – Human Factors;

Access to Resources

12.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory References

12.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Doc 4444 – Procedures for Air Navigation Services – Rules of the Air and Air Traffic Services (PANS-ATM);

ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS), Volume I, Flight Procedures.

Training Material – Safety Letters

EUROCONTROL Safety Letter – Level Bust: a Shared Issue?

EUROCONTROL Safety Letter – Reducing Level Bust;

EUROCONTROL Safety Letter – En Route to Reducing Level Bust.

Training Material – Posters

Level Bust Prevention posters produced by the UK CAA:

2 Many Things

Low QNH – High Risk

Wun Wun Zero

Other Resources

NASA: What Goes Up Must Come Down;

Proceedings of the Royal Aeronautical Society Human Factors Group Altitude Bust Conference – ATC Radar: When it's Not Watching You.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

ATM 2
Reducing Level Busts

1. Introduction

1.1. This briefing note is intended to address matters in which the air traffic controller can make a positive, sometimes proactive, contribution to level bust prevention.

1.2. The purpose of briefing note ATM 1 was to explain the problems experienced by pilots, which may lead to a level bust. In contrast, this briefing note concentrates on issues affecting the performance of the controller.

1.3. Three situations exist:

(a) The pilot deviates from his flight clearance due to misunderstanding of his clearance;

(b) The pilot understands his clearance but nevertheless deviates from it; and,

(c) The controller issues a late re-clearance; the pilot cannot comply with the re-clearance in time and overshoots the re-cleared level.

1.4. In the first of these situations, the normal cross-checking process between pilots may have broken down. Alternatively, the controller may have expressed the clearance in an ambiguous way so that pilot(s) misunderstand his intentions. The controller has an opportunity to prevent a level bust by application of the readback/hearback procedure, although she/he will not be aware if the pilot places a wrong interpretation on a correctly read back clearance.

1.5. In the second situation, it is the responsibility of the pilot not flying (PNF) (pilot monitoring) to monitor the actions of the pilot flying (PF), and this may allow her/ him to prevent a level bust.

1.6. In both the first and second situations, the controller may be able to monitor the actions of the pilots if his work-load permits, while the short term conflict alert (STCA) and airborne collision avoidance system (ACAS) may provide a safety net.

1.7. The third of these situations can only be avoided by issuing re-clearances in sufficient time to allow the pilot to comply.

2. Pilot Misunderstanding of Clearance

2.1. A pilot may misunderstand his clearance for a number of reasons, such as lack of familiarity with the English language. The controller can reduce the chance of misunderstanding by:

(a) The way in which the message is transmitted; and by,

(b) The way in which the readback is checked.

2.2. Use of standard phraseology is of the utmost importance in ensuring that the message is clearly understood. Non-standard phraseology should never be used.

2.3. Transmitting the message in a way that is clearly understood by the pilot involves several steps[1]:

(a) Avoid the use of colloquial[2] language (particularly important when the pilots are clearly not strong English speakers);

(b) Adjust the pace of the transmission (a slow pace may be appropriate if the pilot appears to have poor familiarity with the English language);

(c) Limit the length of messages (lengthy clearances should be broken down into manageable chunks);

(d) Choose wording carefully so that numerical terms are not confused (e.g. heading and flight level);

2.4. When using expressions where a word may be confused with a number (e.g. "descend <u>to</u>

[1] For detailed discussion of communications see Briefing Note GEN 2 – Pilot-Controller Communications.

[2] Colloquial language is the every day informal language used by native speakers.

flight level […]", be aware that the word "to" may be interpreted as the number 2);

(a) Choose wording carefully so that an incorrect meaning is unlikely to be inferred (e.g. when passing a clearance including an expressions such as "Expect FL 250", repeat the cleared level afterwards (e.g. "Report reaching FL 210");

(b) Avoid reference to the level of conflicting traffic (this may be mis-interpreted as clearance to continue to climb [or descend] to the level of the conflicting traffic);

(c) Restate the assigned level on first contact with an aircraft. Some level busts are caused by pilots climbing directly to their requested cruise level when on an SID;

(d) Minimise opportunity for callsign confusion (use full callsign on first contact and whenever similar callsigns increase the chance of callsign confusion).

2.5. Correct readback of clearances is vital to avoidance of misunderstanding. Expressions such as "Roger" or "Copied" are not satisfactory substitutes for a full readback.

2.6. Correct readback checking involves several steps, none of which should be omitted:

(a) Listen carefully to the callsign used to ensure readback is from intended message recipient;

(b) Check to ensure that the readback content is the same as the message transmitted (the controller may detect from his choice of words that a pilot has misunderstood his clearance, e.g. confused heading with flight level);

(c) Check to ensure that the readback is complete (all elements of a clearance must be read back correctly);

(d) Request further readback in case of doubt (or repeat the uncertain part of the clearance) until confident that the message has been correctly understood.

3. Monitoring Aircraft Flight-path

3.1. The controller has no way of knowing if, after a correct readback, a pilot has misunderstood his clearance or is likely to deviate from it (e.g. because he has mis-set aircraft equipment).

3.2. The controller can reduce the incidence of level busts by monitoring the flight path of aircraft under his control to the extent that his work-load permits.

3.3. A busy controller cannot be expected to monitor continuously the progress of all flights under his control. Some form of prioritisation is usually necessary, and experienced controllers often do this subconsciously.

3.4. The controller will already have mentally sorted flights under his control into those which are "in conflict" and those which are "not in conflict"[3] and will have taken action to resolve any conflict by instructing the pilot to change level, direction or speed or any combination of these.

3.5. Priority in monitoring will be given to aircraft whose clearance has recently been changed from a stable situation (e.g. level flight on flight plan route) to a changing situation (e.g. climbing, descending, or changing routing). These aircraft may be either:

(a) Responding to instructions designed to resolve a confliction with other traffic; or,

(b) Proceeding in response to a clearance which they have requested.

3.6. In either case, the intention will be to ensure that they do indeed follow their ATC clearance.

3.7. At the same time, the controller will identify traffic that seems most likely to deviate from its clearance, or which may generate a dangerous situation if it does so. Usually, this is a subjective view based on the controller's impressions, and is hard to quantify.

3.8. The following categories may arouse special concern:

(a) Pilots whose verbal communications do not inspire confidence (e.g. took a long time to get the clearance right);

(b) Poor English speakers;

(c) Pilots unfamiliar with the environment (e.g. general aviation, the military, or airlines not previously encountered);

(d) Traffic new on frequency.

3.9. The monitoring process involves the following:

(a) Looking for deviation from cleared level or heading; instrument departure [SID], change of landing runway);

[3] For an explanation of this process see the Royal Aeronautical Society Human Factors Group Altitude Deviation Conference 15th May 1998: 3. Papers and Comments: *Level Busts and the ATC System* presented by Steve Sharp.

(a) Checking that traffic climbs, descends or alters heading when instructed (this may be at a specified fix or way-point);

(b) Checking that traffic stops climb or descent at the cleared level;

(c) Checking that rate of climb or descent is consistent with clearance.

4. Controller Action

4.1. Most level busts are the result of an action or omission in the cockpit. However, the action of the controller can sometimes result in a level bust.

4.2. The most likely scenario is that the controller issues a late re-clearance to an aircraft to stop its climb or descent. The pilot receives the re-clearance too late to comply and overshoots his level.

4.3. The controller should monitor the rate of climb or descent of aircraft under his controller to ensure that it is consistent with the clearance. In this way, it should be possible to issue a re-clearance in sufficient time to prevent a level bust.

5. Human Factors Issues[4]

General Considerations

5.1. Standard operating procedures (SOPs) are designed to reduce the chance of error or misunderstanding. This applies particularly to the effective use of communications.

5.2. Section 2 of this briefing note dealt with pilot misunderstanding of clearance and discussed effective communication in some detail.

5.3. Controllers sometimes deviate intentionally from SOPs; some deviations occur because the procedure followed in place of the SOP seems to be more appropriate for the prevailing situation. Other deviations are usually unintentional.

5.4. The following factors are often cited in discussing deviations from SOPs:

(a) Task saturation (high workload);

(b) Inadequate knowledge or failure to understand the rule, procedure or action because of:

– Inadequate training; and/or,

– Perception that a procedure is inappropriate;

(c) Insufficient emphasis on adherence to standard procedures, phraseology, etc. during training;

(d) Inadequate vigilance (fatigue);

(e) Interruptions;

(f) Distractions;

(g) Incorrect management of priorities;

(h) Reduced attention in abnormal conditions or high-workload conditions;

(i) Incorrect team resource management (TRM) techniques[5];

(j) Complacency; and/or,

(k) Overconfidence.

5.5. Sound management will identify any of these issues that become prevalent and will take action to address them. This action might include some of the following:

(a) Review of staff establishment, rostering and rest periods;

(b) Review of training, assessment and supervision;

(c) Review of working environment to minimise interruptions and distractions.

Automation

5.6. The increased introduction of automation into a controller's duties also raises human factors issues. The question of harmonisation between automation and the controller is addressed by the EUROCONTROL SHAPE project.[6] Seven main interacting factors have been identified:

(a) **Trust:** The use of automated tools will depend on the controllers' trust in the reliability of many factors such as reliability of the system and transparency of the functions. Neither mistrust nor complacency are desirable;

(b) **Situation Awareness:** Automation is likely to have an impact on controllers' situation awareness. It is important that new systems do not distract controllers' situation awareness of traffic too much;

[4] The EUROCONTROL Human Factors Team deals with a broad variety of topics aimed at the achievement of effective human performance in Air Traffic Management. For details of topics covered and list of publications see the EUROCONTROL web-site www.eurocontrol.int/human_factors/index.html

[5] See Section 6 below

[6] Solutions for Human-Automation Partnerships in European ATM (SHAPE). See also EUROCONTROL documents HF32, 33 & 34: Guidelines for Trust in Future ATM Systems.

(c) **Teams:** Team tasks and performance will change when automated technologies are introduced (team structure and composition change, team roles are redefined, interaction and communication patterns are altered);

(d) **Skill set requirements:** Automation can lead to both skill degradation and the need for new skills;

(e) **Recovery from system failure:** There is a need to consider how the controller will ensure safe recovery should system failures occur within an automated system;

(f) **Workload:** With automation human performance shifts from a physical activity to a more cognitive and perceptual activity;

(g) **Ageing:** The age of controllers is likely to be a factor affecting the successful implementation of automation.

6. Team Resource Management

6.1. Team Resource Management (TRM) is the effective use of all available resources for ATC personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency.

6.2. The corresponding concept of Crew Resource Management (CRM) has been in use among aircraft operators for many years and there is strong evidence to show that these programmes have been successful in reducing accident and incident rates.

6.3. There is also evidence to show that these principles can be successfully applied to air traffic management (ATM). TRM training can reduce teamwork-related incidents and enhanced task efficiency.

6.4. The EUROCONTROL Human Resources Programme[7] is active in the development of a TRM programme, including the development of syllabi, courseware, training modules, training methods and tools.

6.5. The TRM prototype course was prepared in eight separate modules:

- introduction;
- teamwork;
- team roles;
- communication;
- situational awareness;
- decision making;
- stress; and
- conclusion.

6.6. Further developments include two new modules on the management of error and violation and the impacts of automation.

7. Resources

Other Level Bust Briefing Notes

7.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

GEN 1 – Level Busts: Overview;

GEN 2 – Pilot-Controller Communications;

ATM 1 – Understanding the Causes of Level Busts;

ATM 3 – Safety Reporting: ATM.

Access to Resources

7.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from ICAO;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from FSF;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from JAA.

Regulatory References

7.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO – Annex 6 – Operation of Aircraft, Part I – International Commercial Air Transport – Aeroplanes;

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[7] EUROCONTROL Human Resources Programme offers, through the development of methods and tools, a harmonised and integrated approach for:

- manpower planning, recruitment, selection, training and the licensing process,
- the process for integrating human factors into the life cycle of ATM systems.

ICAO Doc. 8168 – Procedures for Air Navigation services. Aircraft Operations (PANS-OPS). Volume 1: Flight Procedures;

ICAO Doc. 9683 – Human Factors Training Manual;

EUROCONTROL Human Resources Programme.

Incident Reports & Training Material

EUROCONTROL Safety Letter: En Route to Reducing Level Bust;

EUROCONTROL: Presentation to 2nd Level Bust Workshop - Human Factors that contribute to Level Busts;

FSF ALAR Toolkit Briefing Note 2.1 – Human Factors;

FSF Accident Prevention 4/98 – Boeing 737 Pilot Flying Selects Incorrect Altitude in Holding Pattern

NASA: ASRS Database Report Set – 50 Altitude deviations;

UK AAIB Report into Airprox at Lambourne;

UK CAA Flight Operations Department Communication – 12/2003 – Airprox Report 105/02 – TCAS Incident – Level Bust;

Training Material – Posters

Level Bust Prevention posters produced by the UK CAA:

2 Many Things

Wun Wun Zero.

Other Resources

FSF Approach & Landing Accident Reduction (ALAR) Toolkit Briefing Note 3.2 – Altitude Deviations;

FSF Digest 11/98 – "Killers in Aviation": Facts about Controlled Flight Into Terrain Accidents;

IATA Report: Problems Around the World with English Language in Civil Aviation;

Proceedings of the Royal Aeronautical Society (RAeS) Human Factors Group – Altitude Bust Conference;

UK CAA Flight Operations Department Communication 2/97 – Altitude Violations;

UK CAA CAP 719: Fundamental Human Factors Concepts

UK NATS – Incidents Around Stacks: A Pilot's View.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

ATM 3
Safety Reporting: ATM

1. Introduction

1.1. The reporting of aviation safety occurrences is important for several reasons:

(a) It allows the causes of occurrences to be investigated;

(b) Based on the findings of the investigation, action may be taken to prevent similar occurrences;

(c) Subsequent occurrence reporting will indicate whether the corrective action was successful;

(d) Important safety information uncovered as a result may be shared with other operators.

1.2. There are three main categories of safety occurrences:

(a) Accidents and Serious Occurrences;

(b) Incidents;

(c) Other Safety Occurrences.

1.3. The basic requirements for the reporting of all types of safety occurrence are laid down by ICAO. For air navigation service providers (ANSPs), these are amplified by EUROCONTROL and by national authorities.[1] Similar regulations are laid down by JAA and by national authorities for aircraft operators and manufacturers.

1.4. Reporting of safety occurrences of all categories is important because it allows an accurate picture of the safety situation to be built up so that timely and effective accident prevention measures can be taken. It is also a valuable tool to judge the effectiveness of such measures.

Accidents and Serious Incidents

1.5. Accidents and serious incidents are defined by ICAO[2] and must be reported. The only difference between an accident and a serious incident is in its result: a serious incident may be regarded as an accident that almost happened.

Incidents

1.6. Incidents are also defined by ICAO[2]. They are occurrences which fall short of the definition of Accident or Serious Incident, but which nevertheless affect, or could affect, the safety of the aircraft. These should be reported to the national authority in accordance with ESARR 2[3].

1.7. Appendix A to ESARR 2 contains a list of ATM-related occurrences which, as a minimum, must be reported and assessed. These include:

(a) Near collision where two aircraft are perceived to be too close to each other, due to:

– Separation minima infringement; or,

– Inadequate separation;

(b) Potential for collision or near collision due to:

– Aircraft deviation from ATC clearance; or,

– Aircraft deviation from ATM regulation;

(c) Aircraft deviation from published ATM procedures.

1.8. In practice, not all such incidents are reported, either because the controller or his management do not realise that they are reportable incidents, or because the controller fears some form of punishment.

1.9. Incidents have occurred where two aircraft operating within the same geographic area have

[1] See Section 6 of this briefing note for details of ICAO and EUROCONTROL regulations.

[2] ICAO Annex 13 Chapter 1

[3] EUROCONTROL Safety Regulatory Requirement ESARR 2 – Reporting and Assessment of Safety Occurrences in ATM;

been issued with the same transponder code. Such incidents have obvious relevance to the level bust issue and should always be reported and investigated.

1.10. Air traffic incidents and airborne collision avoidance system (ACAS) resolution advisories (RAs) should also be reported separately under the relevant incident reporting schemes.

Other Safety Occurrences

1.11. Some safety occurrences are not sufficiently serious to require reporting under a mandatory incident reporting system, but are nevertheless important. These lesser safety occurrences should be reported under a voluntary incident reporting system.[4]

2. Voluntary Incident Reporting System

2.1. A voluntary incident reporting system should be used for reporting all types of safety occurrence, whether or not there is a mandatory requirement to report them to the national aviation authority.

2.2. The total body of safety occurrences may be visualised as an iceberg where only the accidents, serious incidents, and some other reportable incidents are visible above the water line (See Figure 1).

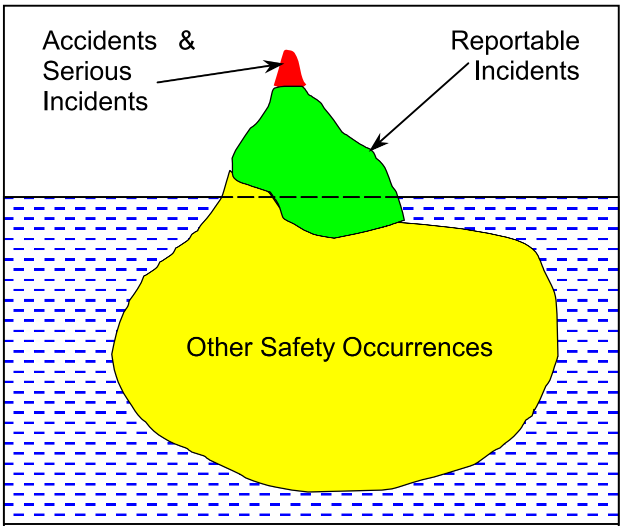

Figure 1 – The Incident Iceberg

2.3. Out of sight lies a large body of unreported incidents and safety occurrences of greater or lesser seriousness, many of which would be made visible by an effective voluntary safety incident reporting system.

2.4. All air traffic controllers and assistant controllers should be encouraged to report safety occurrences of which they become aware, in addition to those for which there is a mandatory requirement, for example:

(a) A level bust almost occurred; the aircraft deviated from its cleared altitude but the critical limit of 300 feet (or 200 feet in RVSM airspace) was not reached;

(b) The pilot failed to read back a clearance for confirmation; or,

(c) Similar callsigns could have given rise to confusion.

2.5. Controllers should also be encouraged to report occurrences where they could be considered to be at fault, whether or not a level bust resulted, for example:

(a) The controller issued an incorrect clearance, which was subsequently corrected; or,

(b) The controller issued a correct clearance which was read back incorrectly, but was not corrected by the controller.

2.6. In the first case, occurrences are usually reported to the Flight Safety department, which reviews the reports and takes appropriate formal reporting action if necessary. The Flight Safety department may also decide to instigate an investigation if appropriate.

2.7. To be effective, a voluntary incident reporting system must have the full support of employees. This implies that:

(a) Employees must not be punished on the basis of evidence contained in voluntary reports where occurrences would not otherwise have come to light;

(b) The confidentiality of reporters must be protected;

(c) Reporters must be confident that the incident reporting scheme is worthwhile and that their reports are acted on.

2.8. ICAO Annex 13[5] states a fundamental principle that should guide all incident reporting:

> *The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.*

[4] ICAO Annex 13 Chapter 8 paragraph 8.2

[5] ICAO Annex 13 Chapter 3 Paragraph 3.1.

2.9. ESARR 2[6] takes a similar line, stating that:

> *…reporting and assessment, which must be in a non-punitive environment, has the potential to act as an effective contribution to accident and serious incident prevention.*

2.10. Usually, a computer database is the most effective means of managing a safety incident reporting system.

2.11. Schemes exist for the sharing of the information contained in such databases while at the same time preserving the confidentiality of the reporter.

2.12. EUROCONTROL policy on confidentiality is contained in guidance material to ESARR 2.[7]

3. Just Reporting Policy

3.1. Full and free incident reporting is fundamental to the establishment of a strong safety culture within an air traffic system. For this to exist, controllers must be confident that they will be treated fairly following an incident report.

3.2. The person reporting an occurrence should be protected from punishment where a genuine error was made that would not otherwise have been discovered, to the extent that this is possible within the law and national aviation regulations.

3.3. The confidentiality of reporters must also be protected so that they are not exposed to humiliation as a result of their reports being made public.

3.4. Managers should bear in mind that operational errors may occur for a number of reasons which are as much the responsibility of the air traffic system as of the controller himself. It is important that they should learn of these system failures and correct them to prevent future unsafe situations. The following are typical examples:

(a) The structure or wording of operating procedures may be unsatisfactory;

(b) Training methods may be inadequate;

(c) A culture may exist where good procedures and sound training are often disregarded;

(d) Equipment design or layout may make a mistake more likely.

[6] ESARR 2 paragraph 2.3.
[7] ESARR2 Guidance to ATM Safety Regulators – EAM2/GUI2: Publication and Confidentiality Policy.

3.5. The voluntary reporting policy should be prepared in consultation with representatives of the controllers unions. It is recommended that the policy should be endorsed by the senior Air Traffic Controller, inserted in the airport Operations Manual and brought to the attention of all controllers and management.

3.6. A draft statement containing the essential elements of a just reporting policy is shown below.

Draft Statement of Just Reporting Policy

The safety of operations is a paramount responsibility of air traffic management and personnel and is in the interests of air transport users, the air traffic management system and its employees; it is therefore important that any event that affects air safety is reported fully, freely and in a timely manner.

The purpose for encouraging any person concerned to report any event or incident that might affect safety is to establish facts and cause and thereby prevent further occurrence; it is not to apportion blame or liability.

The identity of any person making such a report will not be disclosed unless required to do so by the national authority or by law.

Normally, disciplinary action will be contemplated only in those instances in which it is considered that the employee concerned has acted recklessly, or omitted to take action, in a way that is not in keeping with training, responsibilities and/or experience.

In considering the event or incident, favourable account will be taken of the fact that an employee has complied with his responsibilities to co-operate and to report the circumstances of the event/incident.

3.7. Managerial staff at all levels must actively support the company reporting policy and must be seen to do so.

3.8. At first, employees may be suspicious and it may take some time to build up a sufficient level of trust so that they feel confident that the company will honour the spirit of its policy statement.

3.9. A single case of apparent injustice can undermine or even destroy the confidence of employees. It is therefore recommended that when any form of discipline is contemplated, the matter should be discussed with the employees' representatives (controller's union, etc.)

4. Automatic Safety Data Gathering

4.1. Human reporting will always be limited by what can be achieved. Either due to human limitations (e.g. a level bust not detected by the controller), or because the controller does not feel compelled to report certain occurrences, non-reporting will exist. But far more importantly the limitations originate from human factor aspects such as "loss of face" with respect to management and/or colleagues.

4.2. A potential solution to some of these limitations is an automatic safety data gathering (ASDG) system which ensures consistent capture of predefined events.

4.3. The basic principle of ASDG for an ATM system is to:

(a) Connect passively to (and not interfere with) live operational ATM data streams;

(b) Perform an independent analysis and correlation of the data; and,

(c) Detect and store information relating to safety occurrences.

4.4. Alternatively, an ASDG tool could use stored information recorded from an on-line system, or synthetic data from simulations.

4.5. An ASDG tool automatically collects data on flights when triggered by a set of pre-defined criteria. There are two types of trigger:

(a) Reception of ground or airborne system alerts;

(b) Calculation mechanisms built into the tool.

4.6. There are significant issues of professional confidentiality and liability associated with the introduction of ASDG. It is therefore crucial to put in place appropriate procedures that address these issues and ensure an appropriate use of the tool.

4.7. Such systems as the UK SMF (Separation Monitoring Function) or the EUROCONTROL ASMT (Automatic Safety Monitoring Tool) already exist or are in the course of development. The UK tool was supported by both management and controllers. They considered it to be an assurance for everyone that full transparency of the system is achieved.

5. Sharing Information

5.1. Schemes exist and are under development for the sharing of safety information within and between ANSPs. These schemes are important because:

(a) They allow the true dimension of a potential safety issue to become apparent;

(b) They allow controllers and managers to learn that their experiences are not unique – that others have similar experiences;

(c) They permit controllers and managers to learn from the successful preventive measures taken by others;

(d) The effectiveness of national or regional safety measures can be assessed.

5.2. Sharing of information with aircraft operators should also be encouraged as it allows operators and controllers to gain better understanding of the particular problems each experiences.

5.3. In the case of specific air traffic incidents, discussion between operators and the relevant air traffic control service is likely to lead to the best preventative measures being developed.

5.4. The Global Analysis and Information Network (GAIN)[8] is an industry led initiative that promotes and facilitates the voluntary collection and sharing of safety information by and among users in the international aviation community to improve safety.

5.5. GAIN is still under development. However, the Safety Trend Evaluation Analysis & Data Exchange System (STEADES)[9] established by IATA is currently in operation and offers a practical and economical way of sharing information between operators.

5.6. At present, the use of STEADES is confined to airlines; but it is intended to expand the service to embrace other agencies in the future.

6. Regulation

6.1. *ICAO Annex 13* deals mostly with the reporting and investigation of accidents and serious incidents, but Chapter 8 concentrates on accident prevention measures. In particular, it:

(a) requires states to establish mandatory incident reporting systems to facilitate the collection of

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[8] GAIN is an industry led initiative that promotes and facilitates the voluntary collection and sharing of safety information by and among users in the international aviation community to improve safety;

[9] STEADES is the only global safety event database providing analysis of events, with the goal of reducing accident potential and, therefore, costs. It is based on an open, non-punitive, reporting system which is compatible with other reporting systems. STEADES will form an essential part of any Safety Management System.

information on actual or potential safety deficiencies

(b) recommends that states should establish a voluntary incident reporting system to facilitate the collection of information that may not be captured by a mandatory incident reporting system

(c) makes important recommendations concerning the use of incident databases, the analysis of data and the exchange of information with other states.

6.2. ICAO Annex 11 Section 2.26 requires States to implement systematic and appropriate air traffic service (ATS) safety management programmes to ensure that safety is maintained in the provision of ATS within airspaces and at aerodromes.

6.3. This section deals with the establishment of acceptable levels of safety and safety objectives These should be established on the basis of regional air navigation agreements.

6.4. This section also requires that an ATS safety management programme shall, *inter alia*:

(a) identify actual and potential hazards and determine the need for remedial action;

(b) ensure that remedial action necessary to maintain an acceptable level of safety is implemented; and

(c) provide for continuous monitoring and regular assessment of the safety level achieved.

6.5. ESARR 2 requires that each State shall ensure that:

(a) A formal means of safety occurrence reporting and assessment is implemented for all ATM-related occurrences that pose an actual or potential threat to flight safety, or can compromise the provision of safe ATM services, which as a minimum complies with the list of ATM-related occurrences as defined in *Appendix A 2;* and,

(b) Provisions exist for any person or organisation in the aviation industry to report any such occurrence or situation in which he or she was involved, or witnessed, and which he or she believes posed a potential threat to flight safety or compromised the ability to provide safe ATM services. Such provisions shall not be restricted to the reporting of aircraft accidents or serious incidents, since other types of occurrences could reveal the same types of hazards as accidents or serious incidents.

6.6. *ESARR 2 Guidance Material EAM 2/GUI 1* describes the severity classification scheme for safety occurrences in ATM.

6.7. *ESARR 2 Guidance Material EAM 2/GUI 2* deals with publication and confidentiality policy.

6.8. *ESARR 3* deals with the use of safety management systems by ANSPs.

6.9. *ESARR 4* deals with risk assessment and mitigation in ATM.

6.10. Air traffic managers should refer to national legislation to determine how their national authorities have interpreted ICAO Annexes 11 and 13 and EUROCONTROL ESARRs.

7. Resources

Other Level Bust Briefing Notes

7.1. The following Level Bust Toolkit Briefing Note contains information to supplement this discussion:

OPS 7 – Safety Reporting: Aircraft Operators.

Access to Resources

7.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

ICAO documents, which may be purchased direct from *ICAO*;

Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from *FSF*;

Certain documents produced by the Joint Aviation Authorities, which may be purchased from *JAA*.

Regulatory Resources

7.3. Documents produced by regulatory authorities such as ICAO, EUROCONTROL, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 11 – Air Traffic Services;

ICAO Annex 13 – Accident & Incident Reporting;

ICAO Doc 9156 – Accident/Incident Reporting Manual;

ICAO Doc 9422 – Accident Prevention Manual;

EUROCONTROL ESARR 2 – Reporting and Assessment of Safety Occurrences in ATM and associated guidance material;

EUROCONTROL ESARR 3 – Use of Safety Management systems by ATM Service Providers;

ESARR 4 – Risk Assessment and Mitigation in ATM.

Training Material – Safety Letters

EUROCONTROL Safety Letter – Level Bust: a Shared Issue?

EUROCONTROL Safety Letter – Reducing Level Bust;

EUROCONTROL Safety Letter – En Route to Reducing Level Bust;

Other Training MateriaL

NASA ASRS Database Report Set – 50 Altitude deviations;

UK CAA CAP 382 – Mandatory Occurrence Reporting Scheme;

UK CAA CAP730 – Safety Management Systems for Air Traffic Controllers.

EUROCONTROL Second Level Bust Workshop:

Analysis of the Risks of Level Bust;

Level Bust: An Empirical Approach.

Other Resources

NASA: Murphi Busts an Altitude;

UK Airprox Board Report: 2001/2;

UK Airprox Board Report: 2002/1.

This briefing note has been prepared by the Safety Improvement Sub-Group (SISG) of EUROCONTROL to help prevent level busts. It is one of 14 briefing notes that form a fundamental part of the European Air Traffic Management (EATM) Level Bust Toolkit.

The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.

ATM 4
Airspace & Procedure Design

1. Introduction

1.1. The proper planning and design of routes, holding patterns, airspace structure and ATC sectorisation in both terminal and en-route airspace can be effective in reducing the likelihood of level bust incidents. The converse is also true: poorly designed airspace can create situations where a level bust incident is more likely to occur within an air traffic management (ATM) system.

1.2. In an ideal world, airspace design would make it possible for arriving, departing and en-route flights to operate so that they did not have to cross one another, or climb and descend through each other's levels. Furthermore, approach and take-off flight paths would be free of obstacles. Unfortunately, however, this "ideal" design environment is seldom possible, which means that airspace designers need to take steps to reduce the likelihood of level busts by applying several basic principles.

2. General Principles

2.1. As far as possible, arrival and departure routes within a Terminal Airspace should be segregated from each other, both vertically and laterally, thus reducing controller workload; This means that:

(a) Arrival and departure routes should be designed so that aircraft are not required to fly on reciprocal tracks (This can be achieved by ensuring that exit and entry points of the Terminal Airspace are not located in the same place, and that specialised arrival and departure routes are provided to connect the En Route ATS Route system with the Terminal Airspace);

(b) Where it is necessary for arrival and departures routes to cross, the crossing point should be selected taking into account aircraft flight profiles, so that arriving and departing flights will not have a restricting effect upon each other. (To this end, a comprehensive and accurate evaluation of aircraft performance is needed as regards the aircraft operating within the Terminal Airspace, and account needs to be taken of possible nuisance ACAS alerts);

(c) Space permitting, departure routes should be designed clear of holding areas.

2.2. When SIDs and STARs are published with level restrictions, these restrictions should be unambiguously depicted on published charts.

2.3. The application of obstacle clearance criteria in the design of instrument approach and holding procedures by PANS-OPS specialists should strive for simplicity of design. This means that long and complex procedures involving several altitude changes or step clearances should be avoided.

2.4. To the extent possible, lateral and vertical dimensions of ATC sectors should be designed so as to avoid ATC having to provide stepped level clearances, especially over short distances.

2.5. Where use is made of functional sectorisation as a means of sharing ATC workload in a Terminal Airspace, the vertical areas of responsibility of each sector should be unambiguously described in local ATC instructions.

2.6. Where airspace restrictions or reservations are established above or below controlled airspace, it is essential that adequate buffers (dependent on the activity conducted therein) be established above/below these airspace restrictions or reservations, in order to ensure that ATS can provide an adequate margin of safety.

3. ICAO & EUROCONTROL Provisions

3.1. ICAO PANS-OPS[1] provides criteria for the design of instrument approach, holding and departure procedures. PANS-OPS provisions also cover en-route procedures where obstacle clearance is a consideration.

[1] ICAO Doc. 8168, Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS)

3.2. Similarly, ICAO PANS-ATM[2] provides procedures for air navigation services, whose basic tenets form the basis of airspace design.

3.3. Both these ICAO Procedures documents amplify International Standards and Recommended Practices contained in ICAO Annexes 2, 4 and 11 – *see Paragraph 8.4: Regulatory References.*

3.4. For its part, EUROCONTROL guidance material for airspace design and PANS-OPS Procedure design has also been published. The main references include the *EUROCONTROL Manual for Airspace Planning*[3] and *Guidance Material for the design of Terminal Procedures for Area Navigation* (DME/DME, GNSS, Baro-VNAV and RNP RNAV). (Edition 3.0, March 2003).

4. Influencing Factors

4.1. Changes to local airspace can impact greatly on airspace users. In most countries, a mix of commercial, military and general aviation is encountered, with many operators competing for the same airspace.

4.2. The increase in world-wide air traffic means that frequent extensions and adaptations of airspace and its organisation (routes and sectors) are required, but the need to maximise safety should always be the highest priority.

4.3. The design of routes, holding patterns, airspace structures and delineation of ATC sectors is influenced by a variety of factors:

(a) The extent of the navigation, communication and surveillance infrastructure;

(b) Terrain surrounding the aerodrome;

(c) Other ATS routes;

(d) Prohibited and restricted areas;

(e) Proximity of other aerodromes and other airspace structures;

(f) Requirements to ensure environmental mitigation;

(g) Weather phenomena, especially known areas of disruptive weather conditions.

[2] ICAO Doc 4444 – Procedures for Air Navigation Services – Air Traffic Management (PANS/ATM);

[3] Note: Section 5 of this manual, entitled 'Guidelines for Terminal Airspace Design', is to be replaced by a revised edition at year end 2004.

5. Identified Problems

Standard Instrument Departures

5.1. In their final report[4] the UK CAA level bust working group (LBWG) found that a large number of level busts resulted from pilots climbing above standard instrument departure (SID) step altitudes due to misunderstanding information presented on charts. Almost three-quarters of the "SID busts" involved aircraft climbing above a 3000 ft step altitude and over a third were busts of greater than 1000 ft. The following problems were identified:

(a) The complexity of the presentation means that there is a high chance that certain SID charts may be misinterpreted;

(b) For the most part, SID charts are designed by non-pilots and without pilot input. Factors other than safety can be overriding (e.g. noise). Climbing through the First Stop Altitude (FSA) is a very common cause of a level bust;

(c) Some pilots clearly have difficulty in understanding the English used on SID charts;

(d) Multiple frequency changes are often given during the high workload period following take-off and before reaching FSA. This can cause confusion and distract crews from important monitoring tasks;

(e) A number of SID initial turning points use DMEs that are not located on the airfield. This means that on certain SIDs crews should expect the DME reading to decrease whilst on others the opposite is true.

5.2. The recommendations of the LBWG[5] are specific to the problems identified in the report, but will be of value in developing more general solutions to problems.

5.3. The UK CAA reported that more than half the "SID-busts" investigated for the report involved a particular airport. This enabled them to focus remedial action, which included the following:

(a) Raising awareness of issues with flight crew;

(b) Radio warning to pilots;

(c) Discussion with chart manufacturers; and,

(d) Revising the SIDs.

[4] CAP 710 – Level Bust Working Group "On the Level" Project Final Report

[5] UK CAA: Recommendations Originating from the "On the Level" Project

5.4. Within a year the incident report rate had fallen to zero. Occurrence reporting schemes should be able to identify similar examples, enabling corrective action to be taken.

Non-Precision Approaches

5.5. Most controlled flight into terrain (CFIT) accidents may be viewed as level busts, in that the aircraft descends below the prescribed altitude or approach gradient without the prescribed criteria being met. This usually means that the aircraft descends before the prescribed approach fix is reached or while the aircraft is outside the designated approach path.

5.6. A study[6] carried out for the Flight Safety Foundation (FSF) found that in Europe, the risk involved when flying a non-precision approach was 4.1 times greater than when a precision approach was flown. In Europe, approximately one sixth of all approaches flown are non-precision approaches. Where standard arrival procedures (STARs) were absent, the risk of accident was somewhat greater than when they were available.

5.7. Anecdotal evidence suggests that non-precision approaches are sometimes preferred when a precision approach could have been chosen. The investigation into a recent European fatal accident cited as a contributory factor that "The valid visual minimums at the time of the accident were inappropriate for a decision to use the [non-precision approach]".

5.8. Where descent is to commence at a fix (the usual situation), the fix should preferably be overhead a VOR, a defined distance from an airfield based DME or RNAV position.

5.9. A basic problem with some non-precision approaches is that they specify the descent path by means of a series of "fixes" and corresponding check heights, resulting in a stepped descent rather than a stabilised descent. The establishment of a stabilised approach is considered essential for a safe approach and landing; accordingly, a stepped approach is often intrinsically unsafe.

6. Solutions to Identified Problems

6.1. In addition to following the general principles described above (Section 2) and designing airspace in accordance with ICAO provisions, airspace and procedure designers should follow a structured approach when introducing airspace changes. This means that:

(a) Planning is required, so that problems may be properly identified, stakeholder interests addressed, an impact assessment carried out, and a safety assessment completed. Planning also implies that time-scales and milestones are set, so as to ensure that the airspace changes are affected in an organised manner which reduces the likelihood of design 'solutions' creating operational difficulties for either controllers or pilots;

(b) Changes introduced to existing terminal area procedures as well as SIDs and STARs should be properly validated, prior to implementation;

(c) Sufficient time should be allowed in the planning process to allow for necessary controller and flight crew training .

6.2. When RNAV terminal area procedures are designed (excluding the final approach and missed approach segment), procedures should be designed using P-RNAV criteria in accordance with Guidance Material published by EUROCONTROL.[7].

(a) For RNAV operations which rely on a navigation data base (e.g. P-RNAV), State Aeronautical Information Services, data providers and aircraft operators should take steps to ensure the integrity of navigation data in accordance with guidance material published by EUROCONTROL and the Joint Aviation Authorities (JAA)[8];

(b) When introducing RNAV procedures into Terminal Airspace, both controllers and flight crew should be provided with training so that each may understand the effect on the operating environment of the introduction of P-RNAV. (e.g. the effects of introducing "Open" or "Closed" STARs.)

6.3. At one time the process of airspace design was difficult and laborious, being carried out mostly with paper and pencil using manual calculation. Today, a number of procedure-design tools are available to assist in and speed up the design process. Alternatively, the professional services of

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6 FSF Digest 3/96 – Airport Safety: A Study of Accidents and Available Approach and Landing Aids

7 Guidance Material for the design of Terminal Procedures for Area Navigation (DME/DME, GNSS, Baro-Nav and RNP PRNAV) (Edition 3.0. March 2003

8 Information on the introduction of P-RNAV procedures and requirements for ECAC Terminal Airspace is available at the P-RNAV web-site www.ecacnav.com/p-rnav/default.htm

procedure design specialists may be called on to design procedures.

6.4. Two complementary procedure-design tool systems endorsed by ICAO are available: *PD Toolkit* and *PANS-OPS Software*.

6.5. It is essential to ensure the proper training of procedures designers, and that designers have access to the latest innovations, technologies and regulatory criteria. The Australian Civil Aviation Safety Authority (CASA) has produced a manual[9] which outlines standards required for the design of instrument flight procedures and also standards for personnel involved in the design of those procedures. This document lays down Australian licensing requirements for designers.

7. Summary

7.1. Accidents most often happen during departure, or during approach and landing procedures at airports. Analysis of available data suggests that many level busts occur during SIDs. Many CFIT accidents are the result of a level bust during the approach. Careful procedure design can reduce the risk of accidents.

7.2. Where possible, SIDs, STARs and approach procedures, should:

(a) Be standardised;

(b) Be as simple and straightforward as possible;

(c) Avoid step climbs or descents – non-precision approaches should incorporate continuous descent from final approach fix;

(d) Involve a minimum of frequency changes;

(e) Pilots, ATC, airport authorities and other interested parties should be involved in the procedure planning process.

8. Resources

Other Level Bust Briefing Notes

8.1. The following Level Bust Toolkit Briefing Notes contain information to supplement this discussion:

OPS 1 – Standard Operating Procedures;

ATM 2 – Reducing Level Busts.

[9] CASA Manual of Standards Part 173 Instrument Flight Procedure Design

Access to Resources

8.2. Most of the resources listed may be accessed free of charge from the Internet. Exceptions are:

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Certain Flight Safety Foundation (FSF) Documents, which may be purchased direct from *FSF*;

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Regulatory References

8.3. Documents produced by regulatory authorities such as ICAO, JAA and national aviation authorities are subject to amendment. Reference should be made to the current version of the document to establish the effect of any subsequent amendment.

ICAO Annex 2 – Rules of the Air;

ICAO Annex 4 – Aeronautical Charts;

ICAO Annex 11 – Air Traffic Services;

ICAO Annex 14 Aerodrome Design and Operations;

ICAO Doc 4444 – Procedures for Air Navigation Services – Air Traffic Management (PANS/ATM);

ICAO Doc 7030 – Regional Supplementary Procedures (EUR);

ICAO Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations Volume II (PANS-OPS – Construction of Visual and Instrument Flight Procedures);

ICAO Doc 9157 Aerodrome Design Manual;

ICAO Doc 9368 – Instrument Flight Procedures Construction Manual;

ICAO Doc 9426 - ATS Planning Manual;

ICAO Doc 9554 - Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to Civil Aircraft Operations;

EUROCONTROL Manual for Airspace Planning (Edition 2, 2003);

EUROCONTROL Guidance Material for the design of Terminal Procedures for Area Navigation (DME/DME, GNSS, Baro-VNAV and RNP RNAV). (Edition 3.0, March 2003).

Other Resources

Eurocontrol: Recommendations of the Level Bust Task Force;

Eurocontrol Safety Letter - CFIT: The Major Risk;

NASA Altitude Deviation Crossing Restriction Altitude Deviations on SIDs & STARs.

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The authors acknowledge the assistance given by many sources, particularly Airbus Industrie and the Flight Safety Foundation (FSF), in developing these notes, some of which draw on material contained in the FSF Approach and Landing Accident Reduction (ALAR) Toolkit.