



CAP 710

**LEVEL BUST WORKING GROUP
'ON THE LEVEL' PROJECT
FINAL REPORT**

CIVIL AVIATION AUTHORITY, LONDON

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LEVEL BUST ANALYSIS WORKING GROUP

'ON THE LEVEL' PROJECT

EXECUTIVE SUMMARY

Level Busts are a potentially serious aviation hazard and occur when an aircraft fails to fly at the level required for safe separation. In recognition of this potential hazard, CAA established the Level Bust Working Group (LBWG) in 1997: this comprised representatives from Safety Regulation Group (SRG), Directorate of Airspace Policy (DAP) and National Air Traffic Services (NATS). One of the tasks resulting from the LBWG was the 'On the Level' project.

This report presents the work and recommendations of the 'On the Level' project. This project ran from early 1998 to the end of 1999 with its aim *'To identify, monitor and analyse common causal and circumstantial factors for UK level busts and to make any appropriate recommendations for safety improvements.'* To achieve this, a non-CAA project team was appointed by SRG to collect in-depth confidential data not only on **what** happened but on **why** level busts occurred and to make recommendations to the LBWG.

During the 18 month data collection period (July 1998 to December 1999), 626 'level bust' reports were investigated by the project team. In addition, the project team became aware of much anecdotal evidence, which was of limited evidential value, but helped to assess the scale of the overall hazard.

The significant findings from the project are summarised in the report under the following five headings.

- Standard Instrument Departures (SIDs)
- Auto-pilot Problems
- Altimeter Setting
- Pilot Handling
- Standard Operating Procedures (SOPs)

The project highlighted the advantage of short-term in-depth data collection. The CAA did not have to commit permanent resources to the data-collection task but was able to focus resources on a specific problem. It is suggested that the 'snapshot' approach adopted could be considered as a cost-effective way to address other significant generic hazards in aviation or for other hazardous activities.

For each of the five subject areas identified above, the project team identified specific problems and made associated recommendations. All recommendations made have now been addressed by the LBWG and appropriate actions have either been taken or continue to be progressed by the LBWG.

Acknowledgements

This report is the result of a special co-operation between SRG's Safety Analysis Unit, the 'On the Level' team, other SRG Departments, the Directorate of Airspace Policy and the NATS Safety Studies Group as well as with many contacts in BALPA, GATCO, UK airlines and ATC centres.

The author would like to especially thank Capt. David Esson and Capt. Mike Nash ('On the Level' team), Joji Waites (SRG), Dave Martin (NATS-LATCC) and Capt. Donald McClure of ALPA, the originator and driving force of the USAir project.

Adrian Sayce
Head, Safety Analysis

'ON THE LEVEL' PROJECT

1) INTRODUCTION

The safety of all aircraft operations in UK controlled airspace is continuously monitored by the UK Civil Aviation Authority's Safety Regulation Group (SRG) as part of its Safety Regulation Management System. The processes in this system aim to identify significant safety issues so that both short and long-term safety improvement strategies can be developed by SRG in conjunction with industry. The aim of these processes is to maintain or where possible to improve aviation safety.

In late 1997, one of the most significant safety risks in the UK air transport system was believed to be the failure of a serviceable aircraft to fly at its intended altitude or Flight Level and to then lose safe vertical separation in controlled airspace. This operational hazard, commonly called an 'altitude deviation' or a 'level bust', may result in serious harm either from an actual mid-air collision or from a rapid avoidance manoeuvre. Since 1997, the risk of level busts has been the subject of considerable activity in various parts of CAA.

To provide adequate focus for this operational hazard, a joint SRG/Directorate of Airspace Policy (DAP)/National Air Traffic Services (NATS) Level Bust Working Group (LBWG) was formed, chaired by the Head of Air Traffic Services (ATS) Standards Department. The LBWG first met in January 1998 and agreed a programme of work which focused on four areas. These were to be monitored by the following sub-groups:

- Level Bust Awareness Working Group,
- Level Bust Flight Operations Working Group,
- Level Bust ATC Working Group, and
- Level Bust Analysis Working Group (LBAWG).

This report presents the summary and conclusions of a project co-ordinated by the LBAWG. This project, called 'On the Level', involved data collection and analysis and has been described as a 'new look at an old problem'.

Its main purpose was to identify problem areas and to recommend possible solutions to the LBWG for consideration. Therefore, this report does not detail follow-on actions arising from these recommendations.

All recommendations have been addressed by the LBWG and appropriate actions have either been taken or will continue to be progressed and monitored by the LBWG. In view of this changing picture any requests for updates on progress should be made through the Head of ATS Standards Department, Safety Regulation Group, Aviation House, Gatwick, West Sussex, RH6 0YR, UK.

2) 'ON THE LEVEL' PROJECT - BACKGROUND

Level busts have been occurring for as long as there have been efforts to co-ordinate and separate aircraft in airspace. As air transport activity has increased in the UK, so has the number of level busts. These have been monitored in the UK over the years and various reasons for the increase have been postulated at different times.

It was apparent to LBWG members at the start of the programme that there was a general lack of in-depth information on UK level bust events. Although many reports were received by SRG from both pilots and air traffic controllers through its Mandatory Occurrence Reporting Scheme (MORS), these reports (MORs) only provided general information on **what** happened in a level bust event. MORs did not always provide information on **why** level busts occurred and **what** might be done to mitigate the level bust risk.

In order to develop safety improvement strategies to prevent or reduce the number or severity of level busts in UK airspace, it was essential to obtain more information, in confidence, directly from pilots and air traffic controllers on why the specific event occurred. In February 1998 a business case was agreed for an analysis project and in July 1998 the 'On the Level' project was officially launched with the principal aim -

'To identify, monitor and analyse common causal and circumstantial factors for UK level busts and to make any appropriate recommendations for safety improvements.'

3) 'ON THE LEVEL' PROJECT - DESCRIPTION

Prior to launching the data gathering part of the project, it was necessary to agree the reporting framework with all parties involved and to address the critical issue of confidentiality.

3.1) Reporting Framework

Considerable guidance on the reporting framework was provided by a similar project in the US between 1990 and 1992. This project was initiated in 1990 by the major US domestic carrier, USAir. At that time, USAir was generating approximately 3000 flights per day, more than any other airline in the US. Like other US airlines, they were experiencing an increase in the number of level busts and, as a result, USAir management and the US Airline Pilots' Association (ALPA) sought to decrease the number and rate of level busts.

They calculated that each year the total USAir operation generated 100 million opportunities for level busts (see Attachment 1 - page 2-2-1 thro 2-2-3 and Attachment 2 for a similar calculation involving UK airspace). A programme was developed which included enhancing USAir pilot awareness through posters, publications, presentations and discussions, as well as arranging a confidential data collection process. For this process to work a formal agreement was made between USAir, ALPA and the FAA (see Attachment 1 - page 2-2-8) to encourage all 6000 USAir pilots to be involved. In May 1991 this programme was further developed to include reports from six major ATC facilities in the Northeast region of the US.

The arrangements for the 'On the Level' project were different because all UK operators and ATC service providers were encouraged to become involved. The project was initially promoted through the UK Flight Safety Committee, CHIRP¹, BALPA ('The Log'), GATCO ('Transmit') and IPA ('Skypointer'), together with direct contact with airline and ATC Flight Safety Managers. The initial reaction from these direct contacts varied from genuine enthusiasm and co-operation to some degree of suspicion and reluctance to co-operate. In most cases, support was gained during the 18 month period of the project.

3.2) Coverage of Reporting

As for all reporting systems, some degree of under-reporting was expected to occur. This is particularly the case for events involving human error, such as most level busts, because mistakes, omissions or lapses may occur that are simply not noticed or are judged by those involved to be of a minor and insignificant nature (i.e. therefore non-reportable). Alternatively, under-reporting may result from the lack of an open reporting culture within an organisation.

During 1999 the total number of level busts in UK airspace reported through MORS was 455, whereas, the total number of reports handled by 'On the Level' was 451. Although these numbers are similar, it should be noted that there were reports sent to 'On the Level' that were not handled by MORS and vice versa.

¹ CHIRP - The UK Confidential Human Factors Incident Reporting Programme.

To be fully aware of the number of non-reported level bust events that occurred in UK airspace would require an automatic monitoring system. Such a system might compare aircraft achieved flight levels/altitudes with ATC flight level/altitude clearances. It is believed that systems and procedures to assist in this process are feasible for any new ATC centre. In addition, FDR data can be assessed to identify significant flight deviations which may be level bust events.

3.3) Confidential Reporting

The greatest challenge for the 'On the Level' project was to establish an effective means of obtaining in-depth accurate and reliable safety information from both pilots and air traffic controllers. Obtaining such confidential safety information from the start was not expected to be easy, especially when this information might imply that pilots or controllers may have made mistakes, omitted to do things, adopted the wrong procedure or were simply distracted.

This project had the advantage from the outset that there were existing arrangements for confidentiality for the UK MOR Scheme. A statement from CAA's Chairman² made it clear that CAA would not disclose the name of the person submitting an MOR or of a person to whom it related unless required to do so by law or unless, in either case, the person concerned authorised disclosure. If any flight safety follow-up action arising from the MOR was necessary, CAA would take reasonable steps to avoid disclosing the identity of the reporter or of those individuals involved in the occurrence.

An assurance was given that CAA's primary concern was to secure free and uninhibited reporting and that it was not its policy to institute proceedings in respect of unpremeditated or inadvertent breaches of the law which came to its attention only because they were reported under the MOR Scheme, except in cases involving dereliction of duty amounting to gross negligence.

In spite of this reassurance, it was evident that for a few organisations there was a genuine concern amongst their pilots or controllers that the disclosure of such information might be used against them at a later date. Perhaps more surprising, was that some pilots and controllers did not trust existing confidential reporting schemes. There was a genuine fear that *anything* recorded could be used in evidence against them at a later date.

In contrast, some pilots and controllers were very keen and willing to explain in-depth their concerns together with possible solutions. This specific information, which until now had not been collected, was only available to the project team members and proved to be invaluable in helping them to formulate generic recommendations as outputs from this project.

² Page vii, CAP 382, The Mandatory Occurrence Reporting Scheme, January 1993.

3.4) Reporting Arrangements for 'On the Level'

It was essential that reporting arrangements created by the 'On the Level' project would have a high degree of trust and integrity and would not jeopardise current reporting arrangements. To enable this SRG made it clear through a letter from its Group Director (see Attachment 3) that it was only interested in 'generic' factors in level busts and not the details about specific events.

As most level busts resulted from pilot related problems, it was important to commission non-CAA active commercial pilots as the project team so they could talk in-confidence to pilots and controllers about their level bust events without any fear of punitive action. The selection of suitable team members was critical to the success of the project. It was essential that project team members had experience of both pilot and controller operational issues and also had inter-personal skills that would encourage reporters to feel comfortable about discussing a sensitive issue.

The project team were tasked to contact pilots and controllers who had reported a level bust to CAA as an MOR and to systematically obtain as much information as possible to assist in the in-depth investigations of level bust events. In addition, provisions were made for pilots or controllers to report events which may not have been reported to CAA as an MOR.

This arrangement meant that a free flow of information could largely be achieved on a strictly confidential basis with virtually no CAA involvement. Once the data had been collected by the team, any reports that were made available to CAA's Safety Analysis Unit for detailed analysis, were dis-identified to maintain confidentiality.

In order for a report to be 'dis-identified' the following information was removed: the day of the month on which the event occurred, the operator name and, in certain cases, the specific aircraft type. There are some aircraft that are only operated by one airline and hence the disclosure of aircraft type information would directly reveal the identity of the operator. In these cases, the aircraft type was modified to a generic form (for example, twin-engine turbo-prop). In no circumstances was the name of the reporter recorded.

In addition to level busts, the project team chose to record those incidents where a level bust was prevented at the last minute by timely intervention either by pilots or controllers. These were known as 'almost busts' and, in general, their causal factors were invariably the same as level busts.

4) REPORTING PROCESS

Following an initial survey of similar projects, briefing sheets and questionnaires were developed for pilots and controllers, in order to guide the debrief and ensure that relevant details were captured (see Attachment 4).

All UK AOC holders and ATS providers received a comprehensive briefing pack and were invited to participate. They were offered the option of locally debriefing their pilots/controllers or by referral to the project team for direct follow-up. In both cases, the completed questionnaire would be dis-identified by the project team and the details entered into a dedicated Microsoft Access database for use by CAA's Safety Analysis Unit.

Every UK licensed pilot and controller received a briefing sheet in the July 1998 issue of CHIRP's publication, 'Feedback'. They were invited to support the initiative and offered a selection of reporting methods, either through their employers or direct to the project team by Freephone, Freepost, e-mail, Fax, or through the CHIRP office. All briefings emphasised that the 'On the Level' project would be an overlay of any existing reporting systems, which would remain unchanged.

5) INDUSTRY RESPONSE

An encouraging response was received from industry when the project was first proposed. Many smaller companies were eager to take advantage of the initiative from the outset. Some large companies with established human factors investigation systems were initially cautious. However, once assured that the project would operate in parallel to normal systems for a relatively short period of time, they were generally quick to co-operate.

It was apparent from the outset that the project was collecting valuable information. This was largely due to the inclusion of 'almost busts' together with some incidents which were not reported to MORS. Careful application of the questionnaire ensured that maximum detail was obtained for each report to identify contributory factors.

6) BREAKDOWN OF THE REPORTS RECEIVED BY THE PROJECT

During the 18 month data collection period from July 1998 to December 1999, 626 'level bust' reports were investigated by the project team. Of these, 568 involved a 'level bust' of greater than 300 ft and 58 were 'almost busts'. Approximately three quarters of all the reports were formally reported to CAA as an MOR. In addition, the project team have become aware of much anecdotal evidence, which can be of value when assessing the scale of the overall hazard. A summary of the causal factors for all the level busts is shown below.

Category	Count	%
Operation in SIDs	94	15.0
Auto-pilot problems	84	13.4
Did not follow ATC instruction	83	13.3
Altimeter mis-setting	68	10.9
Pilot handling	68	10.9
Confusion over cleared level	51	8.1
Late change of ATC clearance	37	5.9
Callsign confusion	26	4.2
Distraction	21	3.4
Weather	19	3.0
Incorrect ATC clearance	14	2.2
Misunderstood clearance	13	2.1
Climb/descent without clearance	12	1.9
Hdg/FL confusion	11	1.8
TCAS	10	1.6
Finger trouble	6	1.0
Equipment malfunction	5	0.8
Unknown	4	0.6
Total	626	100

Dis-identified information from the project was reviewed at two LBAWG workshops held in February and October 1999. As a result of these workshops, the information was further categorised under the following five major headings so that Problem Statements could be defined and Recommendations made.

- | | |
|-------------------------------|---|
| 1) SIDs | Climbing above step altitudes on departure. |
| 2) Auto-pilot Problems | Integrity of altitude acquisition and uncommanded inputs. |
| 3) Altimeter Setting | Climbing to flight levels with QNH set. |
| 4) Pilot Handling | Manual flying of aircraft in high workload situations |
| 5) SOPs | General operational issues which may contribute to the problem. |

The project's goal was to help SRG to identify the hazards in more detail and to identify possible solutions. Problem Statements were derived from an analysis of the problems or following suggestions from operating crews involved in level busts. These were developed into Recommendations for consideration by the LBWG. There was no attempt to prioritise the Recommendations because the task of assessing the effectiveness of each measure and determining the implementation was beyond the scope of the project.

7) PROBLEM STATEMENTS AND RECOMMENDATIONS

7.1) Standard Instrument Departures (SIDs)

Level busts in this category were the result of pilots climbing above 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 most common airport involved in these reports was Stansted (over half) followed by Gatwick and Luton.

Airport	Count	%
Stansted	52	55.3
Gatwick	14	14.9
Luton	10	10.6
Northolt	6	6.4
Heathrow	5	5.3
London-City	2	2.1
Edinburgh	2	2.1
Leeds	1	1.1
Moscow	1	1.1
Nice	1	1.1

Of the 52 Stansted reports, the individual SIDs 'busted' the most were BUZAD 4R with 28 and CPT 1R with 14.

The situation at Stansted became apparent early in the project and urgent action was taken to address the problem. Awareness of the problem was heightened and changes were made to improve the presentation of information on the chart (see Attachment 5). The result of this action has been a drop in the number of reports involving Stansted. During the first eight months of the project there were 33 reports and in the last ten months there were 19.

Case Study:

Summary: Aircraft climbed 500 ft above cleared step altitude of 3000 ft on Stansted BUZAD 4R departure due to mis-reading of SID chart.

The aircraft was on turn around following a weather diversion. Due to the unavailability of GPU, the crew had to remain on board the aircraft with no food and the destination weather on limits in snow. The flight crew were already 10 hours into their 5th multi-sector day. The First Officer set up the flight system for departure on the BUZAD 4R SID, with 3000 ft correctly set as the first step altitude. During the pre departure brief, the Captain discussed the first step altitude with the First Officer and they agreed that it was actually 5000 ft. This erroneous value was then set in the Altitude Reminder. After departure and passing 3500 ft, ATC alerted the crew to their level bust and re-cleared them to 4000 ft with no loss of separation.

Suggestions made by the flight crew following this incident included:

- Removing intermediate step altitudes from SID charts, since they never apply once RT contact and radar control is established after take-off.*
- The initial SID clearance from ATC should include the first cleared level.*

Problem Statements and Recommendations were:

- 1) Problem Statement** *The complexity of the presentation means that there is a high chance that certain SID charts may be misinterpreted.*

Recommendation *Consideration should be given to a formal Quality Assurance process to assess commercially produced charts against some measure of overall 'reasonableness'.*

- 2) Problem Statement** *SID charts are largely designed by non-pilots and with no external pilot input involved. Factors other than safety can be overriding (e.g. noise).*

Recommendation *The practicability of charts from a flight safety point of view should be assessed and this should include impartial current operational pilot involvement.*

- 3) Problem Statement** *Climbing through the First Stop Altitude (FSA) is a very common cause of a level bust.*

Recommendation

 - a) The FSA should be included as part of the initial departure clearance from ATC.*
 - b) Chart manufacturers should portray the FSA with greater prominence than subsequent altitudes.*
 - c) SID charts should be clarified to emphasise the stepped climb.*

- 4) Problem Statement** *Foreign operators still cause more than half of all level busts in UK airspace. Some clearly have difficulty in understanding the English used on SID charts.*

Recommendation *Review the wording on SID charts to ensure they use the clearest meaning possible to every user, especially those with limited English.*

- 5) Problem Statement** *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.*

Recommendation

 - a) Unnecessary frequency changes after departure and before reaching FSA should be avoided.*
 - b) The departure frequency should be printed on the SID chart.*
 - c) Consideration should be given to removing the ATC 'change to departure frequency' instruction and making it a routine pilot initiated action as part of an upgraded SID SOP. This will enable pilots to safely integrate the normal frequency change and subsequent departure call to ATC with other flight deck activity.*

- 6) Problem Statement *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. This is a recipe for confusion.*
- Recommendation *Airfield DME should be used for the initial turning point wherever possible.*

7.2) Auto-pilot Problems

Level busts in this category were the result of problems experienced with the auto-pilot system. Such problems included uncommanded pitch inputs, failure to level-off due to inadvertent disengagement of the Altitude Select facility and complete auto-pilot failure.

The most common individual aircraft type involved in these level busts was the Boeing 747 Classic (19 reports). Nearly two-thirds of these occurred during the cruise above FL290. Causes for the level busts included: uncommanded pitch deviation, failure to capture new level, auto-pilot disengagement and failure to maintain level in turbulence.

Although the 747 Classic contributes the most reports per individual aircraft type, grouping of aircraft fitted with similar auto-pilot systems results in a larger number of reports. Combining BAe 146 and DHC-8 aircraft, which utilise the same auto-pilot, results in a total of 20 reports. In contrast with the 747, all but two of these level busts occurred during the climb or descent and three-quarters were below FL200. By far the most common cause was the failure to capture a level because of inadvertent disengagement of the Altitude Select facility. A number of flight crew commented on the poor audibility of the Altitude Alert system and that a more prominent warning would have helped to limit the extent of the bust. This audibility issue is particularly relevant for aircraft with high ambient noise levels on the flight deck.

The Swedish CAA have carried out a study with the aim of identifying aircraft equipment that has a positive influence on aircraft levelling-off at selected levels (see Attachment 6). They found that aircraft fitted with an 'approach to altitude' warning tone were less likely to have a level bust than aircraft equipped with just a warning light. They also identified a major problem with a poor design feature on the MD80, which allowed inadvertent de-selection of the altitude capture facility. This was solved with a software upgrade. Now, the only way in which altitude capture at a pre-selected level can be changed is by positively disengaging the auto-pilot or turning the altitude pre-select to another level.

Case Study:

Summary: Aircraft descended 800 ft below cleared level of 4000 ft due to failure of the auto-pilot to capture the level and reduced flight crew monitoring.

During the descent towards the ILS, the aircraft was cleared to descend to 4000 ft. This value was set on the Altitude Selector and confirmed correct by both crew members. The Captain was on the other radio listening to the ATIS as they approached the level-off, but the aircraft continued to descend unnoticed by either pilot until alerted by ATC passing 3200 ft. Neither pilot was aware of any de-selection made to cause the auto-pilot to disarm the Altitude Capture facility. The inadvertent operation of the pitch trim was the best guess at the reason for the disarm. Both crew members were tired and under moderate workload at the time of the incident.

Suggestions made by the flight crew following this incident included:

- *Upgrading the auto-pilot.*
- *Reinforcing the SOP for use of pitch trim.*

Problem Statements and Recommendations were:

- 1) Problem Statement** *The auto-flight system fitted to Boeing 747 Classic aircraft has a history of making uncommanded pitch inputs during the cruise and this has caused numerous, albeit low risk, level bust incidents.*

Recommendation *Consideration should be given by Boeing to recommend to all operators of Boeing 747 Classic aircraft that the altitude exceedence required to trigger the Altitude Deviation System be reduced. **(For example, British Airways has reduced it from 300 ft to 200 ft).***

- 2) Problem Statement** *The design of the auto-pilot fitted on the BAe 146 (and other aircraft of the same era) is such that inadvertent disengagement of the altitude capture facility can result from a number of unrelated flight crew actions and the warning given when this occurs is not very noticeable.*

Recommendation *Consideration should be given to reviewing the minimum acceptable design standard of auto-pilots with regards to integrity of the altitude capture facility. Once programmed to capture an altitude in climb or descent, the auto-pilot should capture this altitude unless the pilot **positively and intentionally** de-selects it.*

- 3) Problem Statement** *On certain aircraft the warning given to alert crews that they are approaching their next selected cleared level is absent or not prominent.*

Recommendation *For manual flight only, a warning chime should sound to alert flight crews of an approaching level and this should be programmed to activate after the '1000 ft to go' point (e.g. at 750 ft to go).*

7.3) Altimeter Setting

Level busts in this category involved flight crew climbing their aircraft to a flight level without first setting Standard Pressure, descending to an altitude without first setting QNH and confusing units of pressure.

Almost two-thirds of the altimeter mis-settings involved aircraft climbing to a flight level with QNH still set. All three level busts resulting from confusion over units of pressure (millibars versus inches of mercury) involved US operators. Low or high QNH was stated as a factor in nearly two-thirds of the reports.

Cause	Count	%
1013 not set	43	63.2
QNH not set	16	23.5
Confusion over units	3	4.4
1013 set early	2	2.9
1013 set late	2	2.9
QNH set late	1	1.5
Flight level similar to altitude	1	1.5

Case Study:

Summary: Aircraft climbed 500 ft above cleared level of FL130 due to failure of flight crew to set Standard Pressure. There was no loss of separation.

The aircraft was flying for an extended period at low level with QNH (997 mb) set when clearance to climb through an area of thunderstorms to FL130 was received. The crew were very busy with weather avoidance and listening to RT. The aircraft's high climb rate and successive heading changes required to avoid Cb build-ups added to the distraction. The result of this was that the crew forgot to set Standard Pressure and climbed to 13,000 ft, which was detected by radar as FL135.

Problem Statements and Recommendations were:

- 1) Problem Statement** *In the UK the altitude at which crews have to change altimeter setting from QNH to Standard Pressure corresponds to the period of highest workload in the cockpit.*

Recommendation *The Transition Altitude should be raised to a significantly higher value (e.g. 18,000 ft) and ultimately this should be common throughout Europe.*
- 2) Problem Statement** *In the UK most SIDs end on an altitude but some end on a flight level; thus requiring an altimeter setting change during a period of often intense workload.*

Recommendation *Consideration should be given to ensuring that all SIDs end on an altitude.*

- 3) Problem Statement** *On days when QNH is low the vertical difference between an altitude (e.g. 6000 ft) and the adjacent flight level (e.g. FL70) can be very small, reducing the time to change the altimeter setting when cleared to a flight level. Moreover, failure to set a low QNH in descent could result in the aircraft flying below MSA unalerted.*
- Recommendation** *When the QNH falls below an arbitrarily low value (e.g. below 1000 mb) a warning should be issued. This warning could be added to ATIS.*

7.4) Pilot Handling

Level busts in this category involved a mixture of flight crew related errors including manually flying the aircraft through the cleared level, levelling the aircraft too late and entering an incorrect value in the Mode Control Panel (MCP).

The climb and descent phases of flight accounted for most of the 'pilot handling' level busts. Out of a total of 68 level busts, 37 occurred during the climb and 19 during the descent. Half took place below FL100.

The most common scenario involved a pilot manually flying the aircraft through the new cleared level, often when under a high workload or with a high rate of climb or descent. There were 33 level busts for which the aircraft was manually flown and of these, 19 reporters described their workload as either moderate or high. Furthermore, there were 18 cases of manually flown Standard Instrument Departures.

Another scenario that contributed to a large number of 'pilot handling' level busts was the entering of an incorrect level into the MCP after having readback the correct clearance. This occurred on 9 occasions.

Case Study:

Summary: Aircraft climbed 700 ft above cleared level of 6000 ft on a DVR SID due to lack of flight crew monitoring during weather avoidance distraction.

The aircraft was climbing at a very high rate following a full power take-off (due to an unserviceable thrust reverser and a wet runway). As it climbed towards the cleared stop altitude of 6000 ft the crew requested a heading change to avoid a large cumulo-nimbus cloud ahead. ATC informed the crew that this would be awkward to achieve due to an inbound aircraft on the ILS and a discussion ensued. During negotiations with ATC the aircraft, which was being manually flown, climbed through 6000 ft. Recovery was initiated at 6300 ft, but because of the high rate of climb a maximum of 6700 ft was reached. Both pilots were taken by surprise by the high rate of climb. However, the aircraft was lightly laden, on a relatively short sector and climbing with a large power excess. Auto-pilot engagement would have increased the monitoring opportunity and helped to reduce workload.

Problem Statements and Recommendations were:

- 1) Problem Statement *High workload manoeuvres in modern advanced technology aircraft (e.g. low weight with high climb rate) are often most securely flown by the auto-pilot. There is a tendency for some pilots to retain manual control too long when the workload unexpectedly increases, or a distraction occurs, and the crew monitoring capability becomes reduced. Instances have been reported where the overloading of one pilot was not detected by the other pilot, and a situation was allowed to develop which may not have occurred if there had been an early reversion to automatic flight.*

- Recommendation
- a) *The risk of degraded monitoring capability, which may occur with an increased workload when maintaining hand-flying currency, should be highlighted (e.g. through the CRM course syllabus, FODCOM and posters).*
 - b) *Operators should consider the adoption of a new Company SOP – the “Manual Veto”. This SOP would encourage pilots to continuously review flight-deck workload when hand-flying, both as PF and as PNF, and to engage the auto-pilot before monitoring breaks down. Using this new SOP either pilot could call for auto-pilot engagement, if they sense a situation developing.*

7.5) Standard Operating Procedures (SOPs)

No report had SOPs allocated as a primary contributory factor. However, issues associated with SOPs, such as non-adherence to or inadequate SOPs, were frequently cited in reports. These included making PAs during climb or descent, frequently obtaining ATIS updates, carrying out paper work during climb or descent, incorrectly flown go-arounds, confusing ATC terminology and multiple ATC clearances.

Case Study:

Summary: 'Almost bust' - Captain entered in the MCP the level he expected to be cleared to rather than the actual level that he had correctly readback. He checked with ATC and discovered the mistake before a level bust could occur.

It was the third sector of the sixth consecutive day at work and the Captain felt "a bit tired but still capable." As the aircraft approached the top of descent at FL270, the Captain was expecting a clearance of "descend when ready FL200 to be level by MCT." The First Officer was off frequency talking to Company about unaccompanied minors when a clearance to descend to FL260 was given. The Captain readback the clearance correctly but set FL200 in the MCP. Twenty seconds later, the aircraft was descending through FL265 at 2000 fpm. At this moment the Captain felt that something was not quite right and so he checked the cleared level with ATC. A level bust was just averted.

Suggestions made by the Captain following this incident included:

- *Ban PAs and Company calls on short sectors.*

Problem Statements and Recommendations were:

- 1) Problem Statement** *Certain operators require their flight crew to make numerous routine departure and arrival calls to Company and these can interfere with the essential cockpit tasks.*

Recommendation

 - a) All unnecessary Company calls should be eliminated and only in an emergency should they be made during climb or descent.*
 - b) PA calls during taxi, climb or descent should be discouraged.*
 - c) PA calls to inform passengers of arrival holding delays should only be made when stable in the holding pattern.*
- 2) Problem Statement** *There is a tendency for some flight crew to spend too much time obtaining the latest ATIS.*

Recommendation

 - a) ATIS updates during descent in good weather conditions should be discouraged.*
 - b) Consideration should be given to widening the parameters that initiate the automatic ATIS update facility, thus reducing the obligation on pilots to collect unnecessary weather information.*

- 3) Problem Statement** *Experience has shown that the missed approach is one of the procedures that attracts the most handling errors.*
Recommendation *Missed approach procedures should be practised in the simulator from different approach configurations and altitudes.*
- 4) Problem Statement** *Certain smaller operators lack dedicated flight operations support. This, together with time pressure, results in flight crew having to carry out paper work during climb or descent.*
Recommendation *Operators should review their procedures to ensure that paper work is not carried out during the climb or descent phases of flight.*
- 5) Problem Statement** *ATC are often forced to issue multiple clearances to flight crew, thereby introducing the possibility of confusion.*
Recommendation *In order to prevent flight crews confusing heading and flight level clearances, ATC should avoid using headings ending in zero.*
- 6) Problem Statement** *Certain ATC terminology can cause confusion.*
Recommendation *Consideration should be given to:*
a) Avoiding the preposition “to” when issuing a climb or descent clearance.
b) Eliminating “expect” clearances.

8) CONCLUSIONS

Level Busts are a potentially serious aviation hazard and occur when an aircraft fails to fly at the level required for safe separation. A level bust can result from problems or combinations of problems associated with the pilot, the aircraft or the air traffic controller. In recognition of this potential hazard, CAA established the Level Bust Working Group (LBWG) in 1997: this comprised representatives from SRG, DAP and NATS. One of the tasks resulting from the LBWG was the 'On the Level' project.

This report presents the work and recommendations of the 'On the Level' project. This project commenced early in 1998 with its aim *'To identify, monitor and analyse common causal and circumstantial factors for UK level busts and to make any appropriate recommendations for safety improvements.'* To achieve this, a non-CAA project team was appointed to collect in-depth confidential data not only on *what* happened but on *why* level busts occurred and to make recommendations to the LBWG.

Of critical importance for the project team was the assurance to all potential reporters that the information provided was to be confidential. To achieve this, CAA provided various reassurances that the project was only interested in generic problems. Any data uniquely disclosed to the team would not be used against a reporter.

In spite of this reassurance, it was evident that a few reporters had a genuine fear that the disclosure of such information might be used against them at a later date. Perhaps more surprising was that some reporters did not even trust existing confidential reporting schemes. There was a genuine fear that *anything* recorded could be used in evidence against them at a later date.

In contrast, other reporters had no such fear and were very keen and willing to explain in-depth their concerns and many even offered possible solutions. This illustrates the real problems when trying to obtain confidential information and it must be accepted that the final data set will be incomplete. However, it is considered that an incomplete data-set does not degrade the relevance of the project findings.

The initial 5 months of the project were spent preparing the method of data collection. This involved formally engaging all the different parties likely to report such events. These included individual pilots and controllers, Flight Safety Officers in airlines and Safety Managers at ATC centres, as well as representative bodies such as BALPA and GATCO. In addition, the CHIRP team provided invaluable support. This phase of the project took about twice as long as originally expected. Upon its completion the data collection phase commenced.

During the 18 month data collection period from July 1998 to December 1999, 626 'level bust' reports were investigated by the project team. Of these, 568 were 'level busts' and 58 were 'almost busts'. Approximately three quarters of all the reports were formally reported to CAA as a Mandatory Occurrence Report (MOR). In addition, the project team became aware of much anecdotal evidence, which was of limited evidential value, but has helped to assess the scale of the overall hazard.

The fact that 75% of all reports were submitted to CAA as MORs suggests that the MOR Scheme has a high catch rate for such events amongst UK operators. This is encouraging, but until a quantitative process can be established (for example, an automatic process to use ATC radar data to check crew compliance with ATC instructions) we can only speculate on the actual reporting rate for such events.

During the data collection phase of the project, analysis of the data was carried out so that actions could be initiated on any significant findings before the end of the project. This ensured that the LBWG was responsive to early findings, but it meant that some corrective actions took place during the time of the project. This was an unavoidable, but desirable outcome.

The significant findings from the project are summarised under the following five headings.

- **Standard Instrument Departures (SIDs)** Level busts resulting from pilots climbing above 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 most common airport involved in these reports was Stansted (over half) followed by Gatwick and Luton.
- **Auto-pilot Problems** Level busts resulting from problems experienced with the auto-pilot system. The most common aircraft involved was the Boeing 747 Classic (19 reports), with causes including: uncommanded pitch deviation, failure to capture new level, auto-pilot disengagement and failure to maintain level in turbulence. Problems were also identified with the common auto-pilot on BAe 146 and DHC-8 aircraft (20 reports), with factors including: failure to capture a level due to inadvertent disengagement of the Altitude Select facility and poor audibility of the Altitude Alert system.
- **Altimeter Setting** Level busts resulting from flight crew failing to select the correct altimeter barometric setting. Almost two-thirds of the altimeter mis-settings involved aircraft climbing to a flight level with QNH still set. All level busts resulting from confusion over units of pressure (millibars versus inches of mercury) involved US operators. Low or high QNH was stated as a factor in nearly two-thirds of the reports.
- **Pilot Handling** Level busts resulting from a mixture of flight crew related errors, including manually flying the aircraft through the cleared level, levelling the aircraft too late and entering an incorrect value in the Mode Control Panel. The climb and descent phases of flight accounted for most of the 'pilot handling' level busts. Out of a total of 68 level busts, 37 occurred during the climb and 19 during the descent. Half took place below FL100.
- **Standard Operating Procedures (SOPs)** Issues associated with SOPs, such as non-adherence to or inadequate SOPs, were frequently cited in reports. These included making Public Address calls during climb or descent, frequently obtaining ATIS updates, carrying out paper work during climb or descent, incorrectly flown go-arounds, confusing ATC terminology and multiple ATC clearances.

By late 1999, the LBWG agreed that sufficient data had been collected. It was never expected to run the project for more than 18 months. Collecting in-depth data beyond this would be counter-productive and reporters would begin to question the value of such a project.

The advantage of this 'snap-shot' approach to in-depth data collection was that CAA did not have to commit permanent resources to the data collection task. For the 'On the Level' project, the project team comprised two external experts who were employed for 7 man-days per month for 22 months. This provided a substantial short-term resource which could provide much greater focus on the quality of the data collected and to support the on-going analysis task.

It is suggested that the 'snap-shot' approach adopted for 'On the Level' should be considered as a cost-effective way to address other significant generic hazards in aviation or for other hazardous activities.

For each of five subject areas identified above, the project team has identified specific Problem Statements and has made associated recommendations as detailed in the report. All recommendations made by the project team have now been addressed by the LBWG and appropriate actions have either been taken or will continue to be progressed and monitored by the LBWG. In view of this changing picture any requests for updates on progress should be made through the Head of ATS Standards Department, Safety Regulation Group, Aviation House, Gatwick, West Sussex, RH6 0YR, UK.

By mid 2000 a number of significant changes have resulted from recommendations made by the project. Some of these were new items, whilst others were existing items now supported by more substantive evidence. The fact that changes have resulted from this project suggests that 'On the Level' has been successful and benefits have been realised for both pilots and controllers.

BIBLIOGRAPHY

1. US Federal Aviation Administration, "Altitude Deviation Study: A Descriptive Analysis of Pilot and Controller Incidents", Final Report, October 1992.
2. Swedish Civil Aviation Authority, "Altitude Deviations", Swedish CAA Investigation Team - Aircraft Technical Equipment Report, July 1997.

Attachment 1

Extracts from FAA Altitude Deviation Study - Final Report: A Descriptive Analysis of Pilot and Controller Incidents

Page 2-2-1 thro 2-2-3:

CHAPTER 2 USAIR'S ALTITUDE AWARENESS PROGRAM

2.1 BACKGROUND

In the spring and summer of 1990 USAir was especially concerned about altitude deviations because it was scheduling approximately 3000 flights per day, the most of any airline in the United States, and it, as other major airlines, experienced an increasing number of altitude deviations. It was at this time that USAir management and ALPA began to look for ways to decrease the number and rate of altitude deviations (Granda, McClure, and Fogarty, 1991).

Before presenting specific data concerning USAir altitude deviations and the basic approach to dealing with the problem at USAir, an analysis of the potential for altitude deviations at USAir, and indirectly at other airlines, will be discussed to put the altitude deviation problem in a proper perspective.

2.1.1 The Altitude Deviation Potentiality

Figure 2-1 illustrates the process used to estimate the number of altitude deviation opportunities for USAir during 1990. The final number, 100 million, is derived from estimating the number of altitude deviation opportunities per altitude clearance, the number of altitude clearances per flight, and the number of flights per year.

The number of altitude deviation opportunities was estimated as ten per altitude clearance. Considering that this number includes both pilot and controller opportunities, this is probably a conservatively low figure. Examples of opportunities which lead to altitude deviations include the following:

- the controller determines and assigns the wrong altitude;
- the controller, inadvertently, transmits the wrong altitude to the cockpit and does not “catch” it in the readback;
- the controller transmits the wrong altitude to the cockpit after which the pilot does not read back the assignment and the controller does not request the readback;
- the communicating pilot receives the correct altitude but reads back another altitude which the controller does not catch;
- the pilot receives the correct altitude, reads back the correct altitude, but enters an incorrect altitude in the altitude alerter or mode control panel;
- the correct altitude is entered in the altitude alerter/MCP but a malfunction causes the setting to “jump” prior to activation;

- the auto-pilot does not capture the mode control panel (MCP) altitude setting; and,
- the pilot takes an altitude assignment meant for another aircraft.

Some of the examples cited have multiple sources of error. For instance, a pilot could enter the wrong altitude in the altitude alerter/MCP because of the confusion that results from similar digits in the speed, heading, or call sign or because he or she anticipated a certain attitude which was not assigned by ATC. Another potential source of multiple error is the failure of the controller to hear an incorrect readback. This could be due to the controller processing information for other aircraft at the time of the readback, disruption of the readback process due to a communication with other controllers, and, of course, the controller could hear the incorrect readback but assume it is correct.

The number of altitude clearances per flight was estimated as ten. Again, this is a conservatively low figure based on pilot and controller inputs for USAir flights, most of which are flown in the highly complex Northeast region airspace.

$\frac{\text{Altitude Deviation Opportunities}}{\text{Year}} = \frac{\text{Altitude Deviation Opportunities}}{\text{Altitude Clearance}} \times \frac{\text{Number of Altitude Clearances}}{\text{Flight}} \times \frac{\text{Number of Flights}}{\text{Year}}$
$\frac{\text{Altitude Deviation Opportunities}}{\text{Year}} = 10 \times 10 \times 1,000,000$
$\frac{\text{Altitude Deviation Opportunities}}{\text{Year}} = \mathbf{100,000,000}$

Figure 2-1. The estimated number of altitude deviation opportunities for USAir during 1990.

The number of flights flown by USAir in 1990 was rounded off to one million for the sake of convenience. The actual number of USAir flights in 1990 was 987,359.

The total number of altitude deviation opportunities for one year shown in Figure 2-1 (i.e. 100 million) is probably a conservatively low number as determined by the rationale given above. A realistic high estimate might be 300 million. This results from estimating 25 for the number of altitude deviation opportunities per altitude clearance, 12 for the number of altitude clearances per flight.

Another way to look at the numbers in Figure 2-1 is that for each flight similar to a typical USAir flight, there are 100 opportunities for an altitude deviation. While the rate of altitude deviations is very low, the extraordinary number of opportunities per flight at USAir and other airlines warrants special attention.

2.2.4.3 Agreement Between the FAA and ALPA/USAir

In order to collect the information needed to analyse altitude deviations in numbers sufficient to approach a representative sample of altitude deviations, it was determined that the pilots had to be “offered corrective action in lieu of certificate action”. In other words, it was acknowledged by USAir, ALPA, and FAA officials that very few pilots would come forth and declare that they were involved in an altitude deviation which they might have caused or contributed to, if the FAA would use that information to prosecute them.

A solution to this dilemma was found in an agreement between ALPA, USAir, and the FAA. The agreement stated that all altitude deviation incidents which came to the attention of the FAA and which were reported by the pilots through USAir’s Altitude Awareness Program, were under the jurisdiction of the FAA Flight Standards District Office (FSDO) 19, in Pittsburgh, Pennsylvania. The FAA exercised its authority for prosecutorial discretion under the tenets of the FAA Act of 1958 and gave the authority to use prosecutorial discretion to FSDO 19. FSDO 19 was responsible for reviewing and possibly remanding the flight crews involved, to the Altitude Awareness Steering Committee (AASC) for analysis and, if necessary, skill enhancement training.

In general terms, the agreement was that a pilot who filed an Altitude Deviation Incident Report would be “offered corrective action in lieu of certificate action” as long as his/her actions did not constitute a gross violation of FAA regulations or create a significant safety hazard. With an aim toward investigating the more serious of the reported incidents, FSDO 19 could request that pilots be interviewed in order to discuss the details of a particular incident. To help in gathering additional information from the pilots during the interview, a committee was established. Aspects of that committee will be discussed in the next section.

Attachment 2

An Analysis of the Number of Level Busts per Level Change in UK Airspace

1) Outline

This study attempts to quantify the probability of an aircraft experiencing a level bust during normal operations in UK regulated airspace. It examines the number of times an aircraft changes altitude during a typical UK flight and then combines this with the number of flights recorded each year in UK regulated airspace and the number of recorded level busts.

It must be appreciated that this study only provides broad guidelines because a number of broad assumptions are made. However, the result should serve some use for the service providers involved in the air transport system to better understand the frequency of the hazard as well as providing a possible monitoring metric for the regulator to use in the future.

2) Number of Level Changes per Flight

During all commercial flights in regulated airspace, aircraft are allocated a number of altitudes or flight levels. It was estimated in the USAir Altitude Deviation Study³ that the number of altitude clearances was ten per flight. This was based on estimates from pilots and controllers involved in operations in the US highly complex Northeast region airspace.

To obtain similar information, SRG examined FDR⁴ data from a UK domestic carrier, operating medium sized passenger jets in European airspace. This FDR data includes the number of times the pilots have changed the flight command altitude settings.

Based on a sample of 36 flights, it revealed 172 changes in selected altitude during the climb and 274 changes during descent. These equate to an average of 4.8 per flight for climb and 7.6 per flight for descent. The overall average number of selected altitude changes for a whole flight is 12.4. This data includes one go-around.

More specifically, the values for departures from and arrivals to London Heathrow airport were:

- 96 changes during climb-out (from 17 flights) - average of 5.6 and
- 161 changes during descent (from 18 flights) - average of 8.9

Hence this suggests an overall average of almost 15 changes in selected altitude per flights to and from Heathrow.

It is accepted that this may be slightly high because pilots may be given a new cleared level before they achieve the last selected altitude. Also, the number of level changes may be higher in the London Terminal Control Area (TMA) than other UK TMAs. To account for these possibilities, it is assumed that there are 10 level changes per flight by commercial transport aircraft in UK regulated airspace (i.e. LC = 10).

³ Altitude Deviation Study: A Descriptive Analysis of Pilot and Controller Incidents - US Department of Transportation, Federal Aviation Administration, Final Report, October 1992, page 2-2-2.

⁴ FDR - Flight Data Recorder.

3) Number of Flights in UK regulated airspace.

Data from NATS shows that there were 1,915,563 commercial air transport movements in UK regulated airspace during 1999. As one flight is two movements, there were approximately 1 million flights (i.e. $FLTS_{1999} = 1.10^6$).

4) Number of Level Busts recorded in 1999

From the UK MORS database, 455 level busts were reported in UK airspace during 1999. From the 'On the Level' project database, 451 level busts were reported in 1999. Although these numbers are similar, it should be noted that there were reports sent to 'On the Level' that were not handled by MORS and vice versa. For the purposes of this study, it was assumed that there was some degree of under reporting of level busts. A more accurate figure would probably be 500 level busts during 1999 (i.e. $LB_{1999} = 500$).

5) Number of Level Busts per Level Changes for 1999.

Taking the above information it is possible to calculate the number of level busts per level change (N_{1999}) for the last year.

$$\begin{aligned} N_{1999} &= LB_{1999} / (LC \times FLTS_{1999}) \\ &= 500 / (10 \times 1.10^6) \end{aligned}$$

$$N_{1999} = 1 \text{ Level Bust per } 20,000 \text{ Level Changes}$$

6) Significance of this finding

For a typical commercial aircraft operating 2,000 flights per annum, experiencing 10 level changes per flight, this results in 20,000 level changes per aircraft each year. From para 5, this suggests that each commercial aircraft will, on average, experience one level bust each year.

Attachment 3

SAFETY REGULATION GROUP

Aviation House
Gatwick Airport South
West Sussex
RH6 0YR

Direct Dial 01293 573078
Direct Fax 01293 573997

Telex 878753



G R Profit
Group Director
Safety Regulation

July 1998

To all AOC Holders and ATS Providers

Dear Sir

‘ON THE LEVEL’ A CONFIDENTIAL LEVEL BUST INFORMATION PROJECT

You should by now be aware of the recent safety initiative launched by CAA to increase awareness of ‘Level Busts’. We have circulated many posters, published various articles in the aviation press and have sent specific advice to all UK operators.

Although we have a lot of information on what happens in level busts through our MOR system, we have less information on *why* they happen. A level bust report on its own is clearly a useful statistic, but of far greater importance is *why* it happened in the first place. This information is of great importance for the aviation community at large because it is only after we know *why* level busts occur that we can develop prevention strategies.

To help us to understand why level busts occur, we have commissioned two non CAA independent airline pilots to manage a data gathering and analysis project called ‘On the Level’. To succeed, the project team will need to obtain detailed information from pilots and controllers who have been involved in level busts. This will not in any way affect the current normal reporting arrangements.

Regardless of how the project team receives this information, only dis-identified information will be recorded. The CAA will, therefore, only have access to the dis-identified information, because the sole aim of this project is to identify prevention strategies, and not to apportion blame, etc. No personal details will be made available to CAA or the reporter’s organisation.

The success of this project will depend on the number and quality of reports received and I cannot over emphasise the importance of every pilot and controller being as open as possible. As the aim is to avoid level busts in the future, it is clearly in the interest of us all to support this safety project.

Yours faithfully

A handwritten signature in black ink that reads 'Richard Profit'.

Attachment 4

Sample Questionnaire

“ON THE LEVEL” PILOTS CONFIDENTIAL QUESTIONNAIRE

Serial No: _____

Please give as much detail as possible by ticking the boxes and adding any notes you wish against any topic. Add further information on page 3 as required.

1. Type of report: Levelbust Almostbust MOR/ASR filed: Yes No
2. Month of incident: Day Night Approx Position:
3. Reporter: Captain First Officer Flight Engineer
4. Aircraft Type & Series: Schedule Charter
5. Weather: VMC IMC Marginal VMC Turbulence
6. Was fatigue a factor? Yes No If Yes give details:
7. Were high rates of climb, descent or a rushed approach involved? Yes No
[Give details]
8. Phase[s] of flight when the incident occurred [tick **all** that apply]:
SID Climb Enroute/level Descent STAR Hold
9. Any constraints: “expedite” / delayed descent, “expect to cross”? Yes No
[Describe]
10. Was a SID “Stop Altitude” misread or misunderstood? Yes No
Details please: Which Stop Altitude?
[Show the problem on a copy of the chart if possible]
Which SID? Which Chart? Aerad Jepp Other
11. Previously assigned level [if applicable]:
12. Newly assigned or correct level:
13. Level entered into Altitude Selector/ MCP:
14. Was there any flightdeck doubt or confusion over the new clearance? Yes No
If Yes - give details - how was it resolved?
15. Was the Altimeter selector setting confirmed by the other pilot? Yes No
16. Was the new clearance written down? Yes No
17. Was a multiple clearance issued? [i.e. Hdg/ IAS/ Level together] Yes No

If Yes please give details:

18. What was the Pilot Flying doing during the incident? [i.e. FMC programming, PA, etc.]
19. What was the Pilot **not** Flying doing? [ATIS, company calls, monitoring, etc.]
20. Flightdeck workload: Heavy Moderate Light
21. Describe any distraction: [i.e. training/ jumpseat pax/ unserviceability]
22. Your readability of ATC: Good Other: [Describe]
23. Were both pilots listening to the r/t? Yes No ANR Headset? Yes
24. Was standard RT used? Flightdeck: Yes No ATC: Yes No
25. Was there any callsign confusion? Yes No
26. Was a "1000 to go" call [or similar] made prior to assigned level? Yes No
27. Was the Autopilot programmed correctly? Yes No Not engaged
28. Did the Autopilot function as expected? Yes No [Give A/P Type if poss]
29. By how many feet did the aircraft actually bust its level? ft
30. Were both pilots "experienced" on type? [say, more than 12 months]
 Captain: Yes No First Officer: Yes No
31. Does your Company SOP actively discourage PAs, ground handling calls, etc. during the climb and descent phase? Yes No
32. Was low/ high QNH a factor? If Yes state mbs Yes No
33. Was QFE/ QNH or Altimeter setting a factor? Yes No
34. Please give a brief, concise description of this incident:
35. What recommendation would you make based on this incident?

If you would like to be available for any further discussion of this incident please enter your contact details here:

or leave blank, as you wish.

Any Questions? Call or Fax on Freephone 0800 328 0792. Thank you for completing this questionnaire and for your valuable contribution to this Flight Safety project.

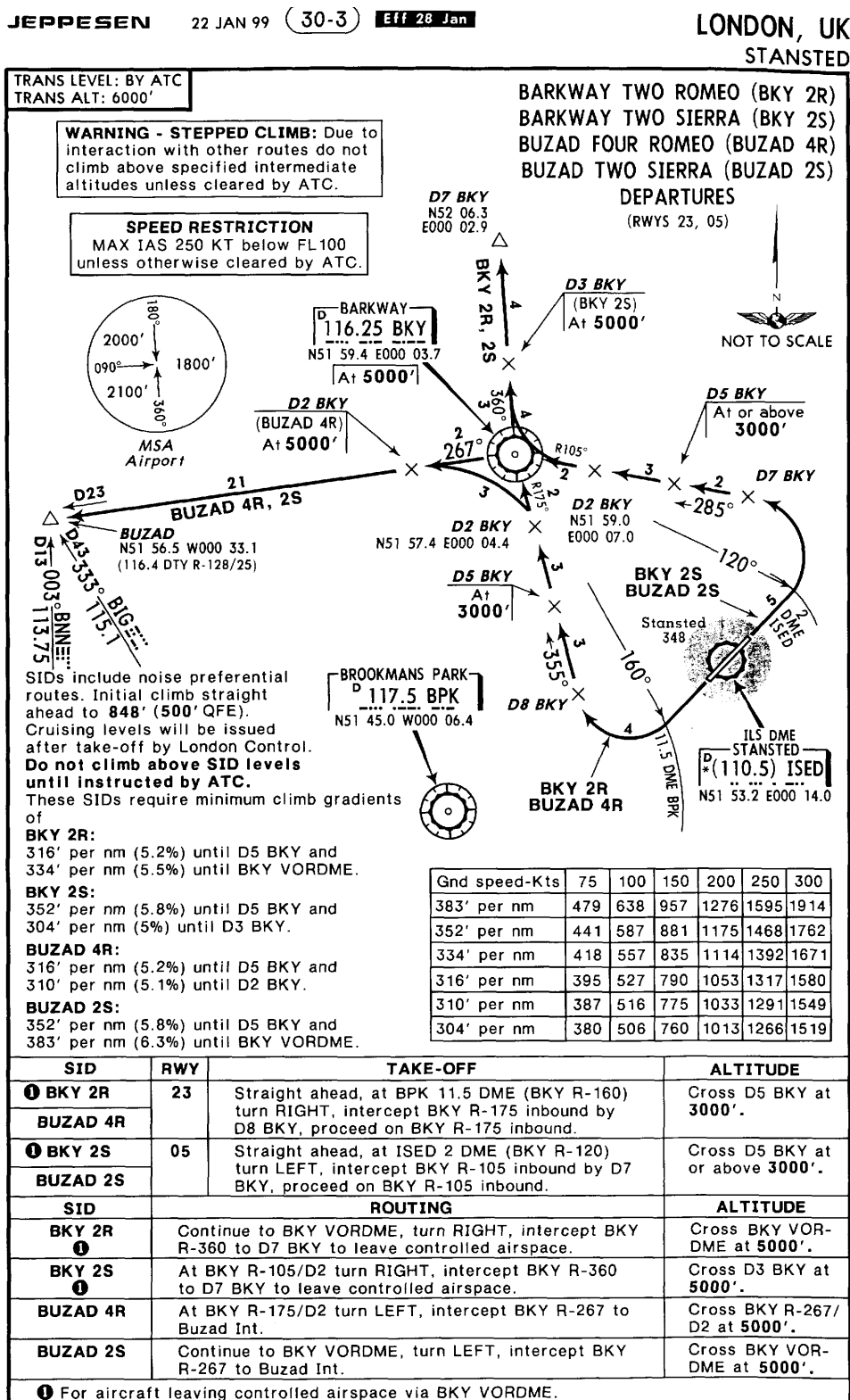
Now please Fax to Freephone 0800 328 0792 or send to "Freepost On The Level", UK

We welcome any comments, suggestions or anecdotal notes which you believe may benefit the project. Please feel free to add these below:

Attachment 5

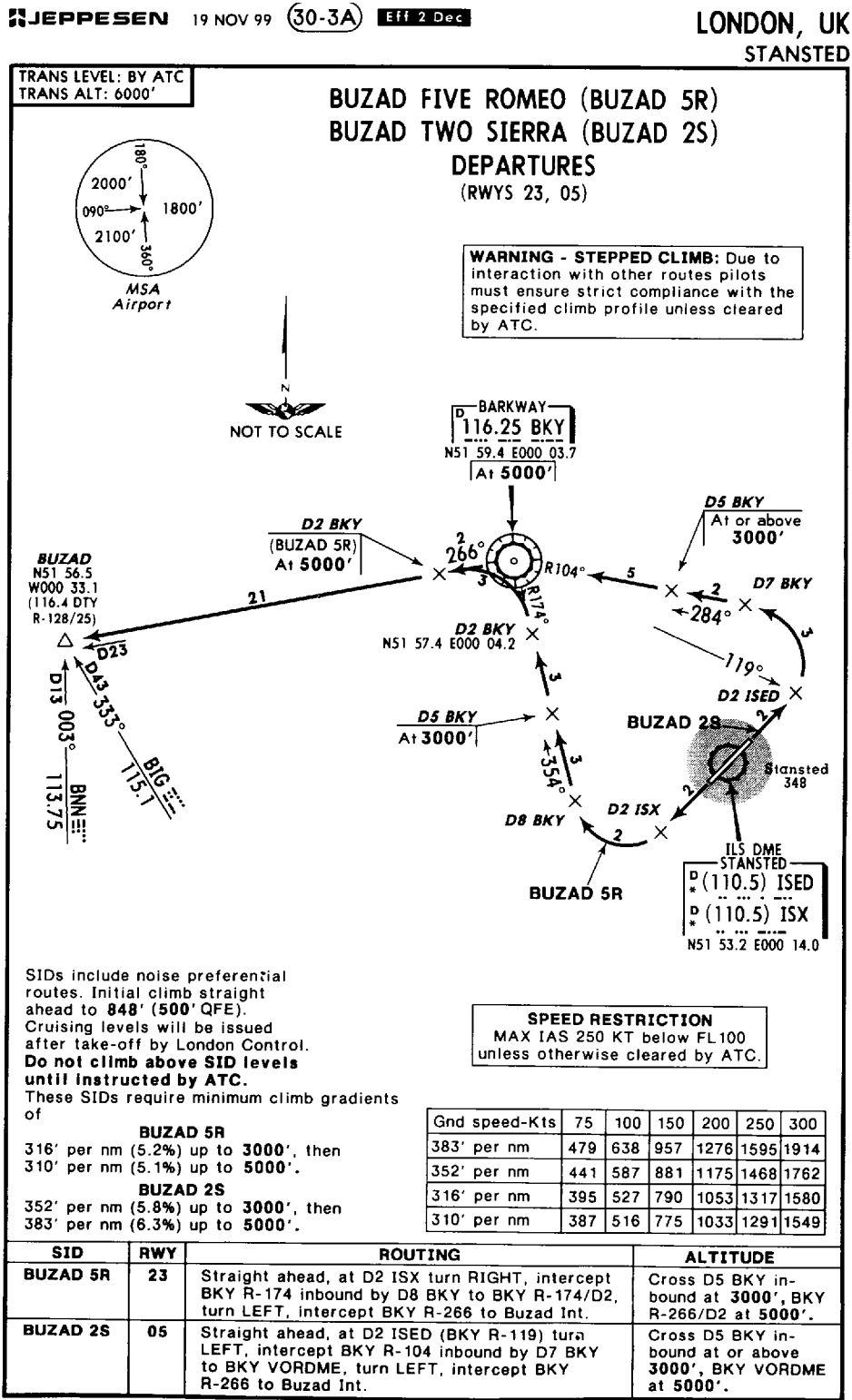
Comparison of Jeppesen BUZAD 4R SID Chart Before and After Amendment

Before Amendment:



The 'On the Level' team discussed with Jeppesen the problems that pilots were having in understanding information presented on this particular chart. Jeppesen's response was to separate the BUZAD and BARKWAY SIDs. This has resulted in a far clearer presentation.

After Amendment: (please note that the SID has been renamed as BUZAD 5R)



It should be noted that 'On the Level' also approached Racal (Aerad), who were equally receptive to ideas for improvements.

Attachment 6

An extract from a Swedish CAA report which identifies equipment that has a positive influence on aircraft levelling-off at assigned and selected altitudes.

Enclosure 4

ALTITUDE DEVIATIONS

Swedish CAA investigation team

AIRCRAFT TECHNICAL EQUIPMENT REPORT

Action Plan

This report is based on a survey among major Swedish Aircraft Operators.

The object was to detect Aircraft equipment, and function of such equipment that have a positive influence on level off at assigned and selected altitude.

Many thanks to participating companies, who have submitted information, by answering selected questions.

ALL PARTICIPATING OPERATORS USE THE TWO-PILOT CONCEPT.

ALTITUDE ALERTER.

A very effective feature in our opinion. Regardless if the Aircraft is equipped with Autopilot or not.

Different system logic noticed: *Light only* or *Light plus additional aural alerter.*

Approaching set altitude:

The Light (normally situated adjacent to the pressure altimeter) or ***Light plus a "momentary tone"*** comes on at 750 ft or 900 ft before the preselected altitude.

When within 250 or 300 ft from preselected altitude, the light goes out.

Deviating from set altitude:

If then a deviation from the selected altitude of more than 250 or 300 ft (depending of logic) is made, The alerter comes on again. ***Light and Tone*** or ***Light and voice warning "ALTITUDE"***.

We like to put a few words in favour for the *"Approach to altitude warning TONE"*.

* When LIN 737-pilots started to fly Falcon's 737 on mixed basis, they noticed the advantage of the alert tone and LIN had their 737 aircraft modified to include this option.

* All SAS DC 9 Aircraft had the approach to altitude “Light and Tone” feature, but the MD 80 aircraft was delivered with just the Light. When later the MD 80's were upgraded with the tone as well, all Altitude Penetrations during manual flight where the pilot failed to level off at cleared altitude ended.

For a period eight DC 9-80 aircraft leased from Swissair were not upgraded. Altitude "Busts" during manual flight continued on that DC 9 version.

For one year now all MD 80's and DC 9-80's have been flying with approach to altitude “Light and Tone”. No report of Altitude Penetration classified as caused by manual flying received since the “**TONE**” was implemented.

* Many prelevel call out's would have been forgotten if not the “TONE” had called upon the pilots attention.

* Quoted from British National Air Traffic Services Level Bust Workshop report Nov.1995. Casual Factors Identified.

Casual Factor No: -15. **COCKPIT WARNING OF REACHING AND/OR DEVIATING FROM CLEARED ALTITUDE**

“The group felt that smaller, business or general aviation aircraft should perhaps be fitted with such devices, which currently may not be a requirement”.

* **The “Light and Aural” warning** seems to be “*Industry standard*” when dealing with deviating from the set altitude.

POSSIBILITY TO CANCEL THE AUTOPILOT AUTOMATIC LEVEL OFF, OR FLIGHT DIRECTOR MANUAL LEVEL OFF GUIDANCE WITHOUT SELECTING A NEW TARGET ALTITUDE.

The goal is to PREVENT that an unintentional manual input **cancels** the armed intended level off altitude **before capture/flare.**

and:

to PREVENT that any push buttons, vertical speed wheel input, or other action **cancels** altitude **capture/flare in progress.**

This was earlier a major problem with the MD 80 aircraft that was solved, by software upgrading Nov. 1996.

In short the MD 80 Flight Guidance computer work like this:

Every time you turn the altitude preselect knob you will automatically arm a new target altitude that is not possible to disarm.(There is always an altitude armed).

During the altitude capture phase, and when flying at APS set altitude. It is not possible to get access to any button or the pitch wheel in order to leave the altitude, unless you turn the altitude preselect to another altitude (which will then be armed), or you have to disengage the autopilot.

This function is also valid when utilising FMS Vertical Navigation function.

One disadvantage with the new software experienced during semiautomatic approaches. You must first reset the APS before you get access to the vertical speed wheel in order to leave initial approach altitude.

This disadvantage is minor compared with what is gained with the upgraded software.

The possibility to make such upgrading on your aircraft type should be investigated, if not already implemented.

SOFTWARE BUGS.

which means: "*Non system design function of the computer*".

The fault research of such software bug problem is often rather difficult, as the same problem is not encountered every day, thus difficult to get relevant data on the occurrence.

In the table attached you will find your reply from the survey.

Text printed in bold letters indicates that there is room for improvement.

RECOMMENDATIONS

- **Carefully re-evaluate upgrade of your aircraft technical standard to conform to the preferred requirement and function stated in this report.**
- **Consider carefully aircraft technical standard regarding mentioned functions when allotting new aircraft to your fleet.**

July 01, 1997.

For CAA investigation team.
Engstrom/Hamnstrom/Bode'n