

2 Analysis

2.1 Roll control problem

Analysis of the flight recorder parameters showed that the flight controls were serviceable and functioning normally during the full and free control checks. The subsequent response of the aircraft to control inputs also appeared normal until the final approach to land at Gatwick. The requirement for significant control wheel inputs during this approach to land appears to be related to the selection of flap angles greater than 25°, when just under half of the available control wheel authority was necessary to maintain wings level flight. This is consistent with the fact that the leading edge of the fore-flap becomes exposed to the airflow at flap settings of 25° and above, when the effects of the discontinuity in the flap leading edge produced by the omission of the panels would begin to take effect.

Furthermore, given that the aircraft handling was normal on the flight test after the missing panels 666AR and 666BR had been reinstalled and that there have been no further reports of handling problems since the aircraft re-entered service, the roll control difficulties experienced during the flight were as a direct consequence of the asymmetric aerodynamic effects induced by the missing access panels on the right hand outboard flap.

The investigation therefore concentrated on the sequence of events that resulted in these panels being left off the aircraft.

2.2 Hot oil/electrical burning smells

No defects were found in any of the cabin utilities that could account for the electrical burning smell reported by cabin crew. The failure of the No 2 aft equipment cooling exhaust fan could be ruled out as a possible cause, given its remoteness from the cockpit and forward cabin where the smells were reported and the absence of evidence of overheating of the fan.

The hot oil smell in the cockpit was reproduced during the engine runs after the incident and as it was only present when the engine bleed air sources were selected, the problem was most likely associated with the engines. The strip examination of the left engine, removed because of high oil consumption, failed to identify any defects that could have produced the oil hot smells.

According to the aircraft manufacturer, Boeing Commercial Airplane Company, and the engine manufacturer, Rolls-Royce PLC, overfilling the engines with oil can cause hot oil smells in the cockpit and cabin. This is borne out by in-service

experience from Boeing 757 operators. This issue was also highlighted in AAIB formal report 1/2004 during which it was identified that the operator of G-CPER had the highest rate of reporting of oil smell incidents. The Powerplant Technical Department had taken extensive measures in trying to address the problem, including placarding the engine oil servicing access doors and issuing specific instructions and reminders to maintenance staff of the importance of complying with the Aircraft Maintenance Manual instructions.

Notwithstanding the above, the Maintenance Organisation's maintenance planning process did not take into account the Aircraft Maintenance Manual requirement to service the engine oils between 10 minutes and 1 hour of shutdown, so that the maintenance staff both in the hangars and on the Ramp were placed in a position where they often could not practically comply with the requirements.

2.3 Conduct of the maintenance

2.3.1 General

The technicians and LAEs involved in performing and/or certifying for the tasks of installing flap panels 666AR/BR and servicing the engine oils on G-CPER did not carry out the work to the required standard of airworthiness. This incident was the result of the failure to meet these standards.

The investigation found that the maintenance errors were not the result of willful negligence, or any desire to perform a less than satisfactory job, but the result of a combination of systemic issues, that had increased the probability of an error being committed. Both technicians had followed the accepted 'normal' practices in their work area and believed that they had acted correctly in doing so. Both individuals had shown commitment in performing their tasks and yet the tasks were not completed satisfactorily.

The procedures and instructions used for installing the wing access panels and servicing the engine oils were poorly engineered from a production engineering standpoint and were prone to cause error, however well performed, as this incident showed. The lack of consideration for the maintenance environment in planning these tasks was a major contributory factor.

A further contributory factor was the lack of oversight and guidance by the LAEs responsible for the technicians. This may be due to the fact that they do not have any supervisory responsibilities and they therefore do not see it as their job to monitor the actions of the technicians.

Whilst the LAEs and technicians involved were focused on completing the tasks in a timely and diligent manner, they did not seem to be aware of the implications on airworthiness of their actions and did not fully appreciate their responsibilities for ensuring compliance with the required airworthiness standards.

2.3.2 Procedure for controlling access panels

2.3.2.1 General

The practice of fitting and certifying for access panels as a 'batch' job, rather than sequentially would seem to be widespread practice within the Maintenance Organisation, given that this practice was in use at both the Heathrow and Gatwick maintenance bases. It was apparent that such a practice had evolved due to the remoteness of the job card racks from the work areas. Maintenance staff clearly perceived it to be more efficient to install all of the panels first, and then certify the job cards, rather than wasting time travelling back and forth to the job card racks on multiple occasions. Unsurprisingly, they had dealt with the more immediate problem of how to perform the task in the most economical manner, but they were not aware of the less obvious issue of the effect that this would have on the level of airworthiness control.

This incident, and that of the in-flight loss of the ADU access door on B777 G-VIIA, suggest that the Maintenance Organisation's procedures for the control of access panels are not sufficiently robust.

2.3.2.2 Flap panels 666AR and 666BR

The technician who certified for fitting these panels went to significant lengths to ensure that, in his view, the job was performed correctly. His decisions are not thought to have been affected by fatigue or environmental factors; he was influenced to a much greater degree by established working practices in the TBD Bay 13 hangar.

By certifying for the fitment of the panels, a task that he had not performed himself, the technician exceeded the scope of his company authorisation. However, the investigation determined that his was not an isolated case. The lack of discipline in certifying for work in a timely manner meant that it was not unusual for individuals to be in a position where they would be asked to certify for a task performed by someone else, who had gone off shift without certifying for the work completed. Faced with this problem, rather than incur potential delays in production, maintenance staff would attempt to verify that a task had been completed before certifying for it themselves. The logical response would

have been for supervision to manage their maintenance staff to ensure that all work was certified for as soon as it was completed, however, there were no staff acting in a supervisory capacity on the shop floor to take such action. Thus, a culture of 'blind stamping' job cards had developed, which after a period of time became accepted as 'normal' practice. The fact that this practice was prevalent at both the Heathrow and Gatwick maintenance bases, rules out the local culture within certain areas as being the primary causal factors. The problem of duplicate sets of panel job cards served to further encourage the practice of blind stamping, in that LAEs and technicians had become conditioned to expect to have job cards outstanding, even though all the maintenance tasks had been completed.

The technician's willingness to stamp off the job cards for installing panels 666AR and 666BR was thus a reflection of the 'normal' practices, rather than a wilful deviation from approved procedures and does not seem surprising given the above evidence. There is no reason to believe that another technician would not have done the same in his position.

Having misinterpreted the panel diagram, inspected the wing and found no evidence of missing panels, and being conditioned to 'expect' to see unstamped job cards for work already completed, the final link in the chain leading to the incident was the technician's assumption that the panels must already have been installed by another technician. This conclusion was almost inevitable given the picture of the situation in his mind at the time.

Notwithstanding his deviation from approved procedures, it could be argued that the incident was caused by the technician failing to recognise that the flap panels are hidden by the flap drive fairings when the flaps are retracted. However basic the error may appear with hindsight, such errors cannot be entirely eliminated from human performance and aviation history is filled with accidents caused by fundamental errors caused by misinterpretation or relying on assumption. It is recognised in the aviation industry that human error cannot be entirely eliminated and where an error could prove critical, systems and procedures are put in place to capture it or mitigate its effects. Examples of this include the cross-checking of instrument settings by both pilots, or duplicate inspections in maintenance on flight critical systems. There was no requirement for a duplicate inspection of the installation of panels 666AR/666BR and panels are not normally required to be duplicate inspected, these not being considered safety critical items.

The technician's error could have been caught had the flap panels 666AR/BR been found during the inspection of the hangar racking prior to the aircraft leaving the hangar. It was unfortunate that they had been placed with similar

looking slat panels that were not required to be refitted, hence the flap panels were overlooked.

2.3.3 Engine oil servicing procedures

The fact that technicians in the hangars and on the ramp would deviate from the Maintenance Manual instructions for servicing the engine oil without query, is a matter of concern. Even if they had not consulted the Maintenance Manual instructions, the intent of the instructions was included in the instruction sheet that forms part of the 'Daily Check' document, which clearly specified the time limits for checking the engine oil levels. The technicians appeared to have a mind set of simply performing the tasks as presented to them by their LAE or Shift Manager, without recourse to the Maintenance Manual instructions. It may be that they simply deferred to the instructions of their more experienced LAE/Shift Manager, or there may have been a general perception that the requirement to check the engine oils within the specified time period, was not really that important, given the basic nature of the task.

With the aircraft still in the hangar docking, the technician servicing the engine oils on G-CPER, had he followed the correct procedure, would have had to have taken positive action by deferring the oil servicing task until after the engine runs had been completed. Had he done so, the work might have been performed correctly on this occasion, but this could not be guaranteed the next time, and is this unacceptable from an airworthiness control standpoint. The random order in which the 'Daily Checks' were performed on the Ramp also resulted in failure to comply with the Maintenance Manual instructions. The absence of adequate maintenance planning to ensure that the engine oil levels were checked within the required time period in both heavy maintenance and operational areas constituted a systemic issue that rendered compliance with the approved instructions very difficult in some cases.

2.3.4 Behaviour and actions of the LAEs

2.3.4.1 Panels 666AR and 666BR

The Quality Investigation Report into the incident highlighted that the LAE had played a contributory role, by handing the technician a bunch of job cards to stamp. The technician's natural reaction was to follow the instructions of the LAE, he being far more experienced. It is not surprising that he failed to challenge the LAE's request when he was asked to clear the batch of panel cards handed to him, and had he done, it may not have been well received by the LAE. The LAE's actions in tasking the technician in this manner could be questioned, as with foresight it was likely to encourage him to stamp all of the panel job

cards handed to him, which is exactly what happened. It could also be asked as to why the LAE in charge of the task of re-panelling the right wing, who should have had a greater awareness of the airworthiness implications, did not ensure that the panels were installed sequentially, with each panel job card being stamped immediately after installing the panel. The fact that this did not occur seems to be a reflection on the general lack of discipline in the control of the fitment of access panels.

2.3.4.2 Certification for engine oil servicing task

It is a matter of concern that the LAE responsible for certifying for the engine oil servicing task on G-CPER certified for the task purely on the assumption that the technician had completed it correctly, particularly given that he observed the technician draining oil from the engines, which is not normal practice. The LAE's general lack of awareness of the technician's activities and the correct procedures for servicing the engine oils, specified in Alert Temporary Revision 12-593, had further compromised the standards of airworthiness.

2.4 **The Maintenance Organisation's Quality Assurance Programme**

The EQS department, through its comprehensive procedures, scheduled auditing and Product Sampling programmes and the GFOR system complied with the JAR-145 requirements for an airline quality system. However, it was apparent that the department's level of oversight of activities in the TBD hangar and in operational areas was very limited. The ½ a day per month on average spent in the 'TBD' hangar was clearly insufficient time in which to gain a thorough understanding of the working practices being used and how they compared with the company's procedures. Quality compliance audits are not particularly effective in identifying behavioural issues that have the potential to compromise standards of airworthiness, as they look at the outputs of the processes and not necessarily how they are performed. These issues can only be understood through spending a suitable amount of time in the maintenance environment and working with staff to understand the factors that influence their working practices. It is therefore not surprising that the Quality Engineers were unaware of the actual practices in use on the shop floor and the detrimental effect that such practices might have on airworthiness control.

It was also apparent that the GFOR system and Product Samples in the 'TBD' hangar had not highlighted any problems relating to the control of access panels or the procedure for servicing the engine oils. These issues were either not perceived as being problems, or if they had been, they were not thought to be worthy of reporting via the quality system.

2.5 Supervision and organisation of hangar staff

The guidance and example set by supervision can have a strong influence on working culture. There was evidence of a lack of adequate leadership displayed by the LAEs involved with the G-CPER incident, in that they did not have sufficient oversight of how the tasks were being performed, and did not ensure that best practices were being used. They also displayed an over-willingness to rely on assumptions, rather than verify that work had been performed correctly.

This behaviour may simply be a reflection of the lack of clarity of the role that the LAEs are expected to play in terms of leadership, given that they have no responsibility for man-management and thus do not see it as being their job to monitor the performance of the technicians, nor to provide them with advice and instruction on best practice. The lack of discipline shown by technicians in certifying for work in a timely manner may have concerned the LAEs, but with no supervisory responsibility they would not have been in a position to take effective action against the problem. The fact that the composition of the maintenance crews changes with every aircraft input may be a further hindrance to maintaining consistent standards and practices. It is unrealistic to expect the Shift Manager to be able to achieve this, given the large number staff who report to him, his remoteness from the work face and his broader responsibilities.

It is not sufficient to issue maintenance staff with authorisations and expect that they will always stick to them rigidly whilst ignoring all external pressures and factors applied to them in the workplace; this is ignoring the influence of human factors. Simply relying on procedures and assuming that people will always adhere to them is unrealistic and can, over a period of time, result in a gradual shift in the norm away from best practice as people inevitably respond to the most pressing environmental and peer influences around them. This is a risk that is more apparent in a regime of Quality Assurance, where more responsibility is placed on the individual and there is less independent checking on the quality of individuals' work.

It was apparent that working practices had evolved in the 'TBD' hangar that were expedient in getting the job done, but not necessarily consistent with maintaining high standards of airworthiness and were in some cases deviating from approved company procedures. This was not a conscious, deliberate compromise of standards, but rather an invisible erosion of standards based on the more pressing need to 'get the job done' in as expedient a fashion as possible, which is a natural trait of engineers. The implications on standards of airworthiness of adopting certain procedures and methods are not always obvious at first sight and an awareness that standards might be compromised requires a certain degree of training, experience and awareness of airworthiness

issues in general. Without a continual focus on airworthiness standards, through training, effective supervision and adequate quality monitoring, it is inevitable that staff will deviate from best practices.

2.6 Similarities between the B777 (G-VIIA) and G-CPER incidents

The AAIB's investigation into the loss of a B777 (G-VIIA) ADU access door highlighted similar issues of lack of discipline and control of the certification of access panel tasks at the Airline's engineering base at London Gatwick. The issues of duplication of panel job cards, remoteness of the job card racks from the work area and staff failing to certify for work in a timely fashion were also identified in the G-VIIA investigation. Given that these findings were obtained by a different AAIB Inspector in independent investigation, the findings suggest that such issues may be widespread throughout the maintenance organisation. In this context, the technician's action in 'blind stamping' for fitting panels 666AR/BR on G-CPER seems not to have been an isolated case, but more symptomatic of the existing culture.

2.7 Conduct of the Maintenance Error Investigation

It is believed that no formal record of the MEI process on G-CPER was kept and thus the AAIB cannot comment on the method in which this was conducted.

It was clearly apparent, from comments received from a representative cross-section of maintenance staff, including technicians, LAEs and Shift Managers, that the Maintenance Organisation's MEI process was perceived as lacking in fairness and objectivity and was seen as being too closely tied to the disciplinary procedure. The staff believed that this was counterproductive to maintaining an open reporting culture.

The UK CAA's view on Maintenance Error Management systems is that if the lapse by the employee is unpremeditated or inadvertent, the employer would be expected to act reasonably in the interest of full and free reporting, so that the contributory factors to the incident can be established, with every effort being made to avoid action that may inhibit reporting.

The maintenance management's decision to take disciplinary action against the technician who certified for installing flap panels 666AR and 666BR, that he did not fit himself, seems inappropriate, given the significant systemic issues identified in both the AAIB's investigation and the EQS department's Quality Investigation. This is more so, given that the maintenance management were aware of and openly accepted the fact that 'blind-stamping' of maintenance tasks occurred.

Given that the technician did not display willful negligence and followed the 'accepted' working practices in his area, whilst exhibiting a desire to do a satisfactory job, the value of disciplinary action in this case seems to be questionable and in failing to address the underlying reasons for 'blind stamping' of job cards, is unlikely to have a long-term effect on staff behaviour.

2.8 Role of the Safety Services Department

The staff in the Safety Service's Department were well-motivated and saw their role as being important in providing an independent oversight of safety matters across the Airline. They believed that their task was not to apportion blame, but to help to identify and address the organisational issues that contributed to safety incidents, with the aim of preventing recurrence.

It appeared, however, that their effectiveness was limited in some areas by the lack of clarity in some of their departmental procedures and a lack of clarity over what authority and powers it held. For example, they believed that in the event of a serious incident occurring, the Safety Services department would lead the Airline's internal investigation, with this investigation taking precedence. This did not seem to be clearly reflected in procedures, and the Maintenance Organisation in any case did not seem to agree with this viewpoint, choosing to conduct their own independent investigation into the G-CPER incident.

Whilst the Airline's Operational Safety and Quality Management Manual specified that safety recommendations should be tracked via 'eBASIS' and the Board Safety Review Committee, there was no information provided on how to ensure that the responses to the safety recommendations were received in a timely manner. There was similarly no instruction on the action to be taken should the response to the recommendations be unsatisfactory. It is unsatisfactory that the department had placed safety recommendations on 'eBASIS' relating to improved procedures for the control of access panels and the servicing of the B757 engine oils, and for the Maintenance Organisation to have failed to provide a response in a timely manner.

It was apparent that, having conducted its own independent action into the incident, the Maintenance Organisation had taken its own actions to address the issues. This is entirely appropriate and as it should be, however, it appeared to the AAIB that the safety management loop had not been closed in that the actions taken had not been formally recorded on 'eBASIS' and the Safety Services recommendations remained open with no response from the Maintenance Organisation.

It would seem appropriate for the Safety Services department to review its' working practices and procedures to ensure that more robust controls are put in place for monitoring safety issues and in particular, to ensure that it has sufficient authority to manage such issues to ensure satisfactory resolution from the Airline's perspective.

2.9 Consequences of failing to install or secure critical panels

The omission of the flap panels on G-CPER produced a significant detrimental effect on the handling of the aircraft. The size and weight of the ADU access door that detached from B777, G-VIIA was such that it could conceivably have caused significant damage to the aircraft or serious injury to persons on the ground. Such consequences suggest that the widely adopted industry view that the fitting and securing of access panels is not a critical task is not always valid. It would seem to be prudent that panels be considered as to their criticality, based on their size and location and the likely effects if they are either omitted, or should detach from the aircraft if incorrectly secured. It would seem reasonable that panels that could significantly hazard the aircraft or persons on the ground, should require an independent inspection after fitment or closure.

2.10 Flight crew actions

The flight crew made a positive decision to action the emergency checklist and don their oxygen masks in a timely manner. This was a prudent course of action, given that experience shows that pilot's well-being and judgement can be affected by exposure to engine oil fumes. Had they not taken this action, the subsequent handling difficulties on the final approach to London Gatwick could have been further compounded, increasing the degree of risk.