



Maintenance Briefing Notes

Human Performance

Error Management

I Preface

I am pleased to present the second issue of the Maintenance Briefing Notes. Further to the first issue, we received positive feedback from a number of you, encouraging us to continue in the same spirit.

I would like to thank everyone involved in preparing and publishing this new issue.

This second Maintenance Briefing Note will report on the results from a recent airline survey focusing on maintenance personnel and their perception on human factors and maintenance errors, as well as provide a case study related to engine cowl loss in flight.

The case study re-emphasizes that despite advanced technical prevention methods, the human being, by strict adherence to procedures, is an essential element in the chain to prevent maintenance errors from occurring.

I look forward to your feedback and comments following this issue. We are also always open to any suggestions for future issues that will apply to contemporary matters relating to human factors in the industry today.

Frank Schreiber

VP Maintenance Engineering Services

II Learning from the Maintenance Environment

Communication of technical incidents today are well documented, with well established communication lines and processes between the operator and the manufacturer.

A number of incidents are related to maintenance operations and maintenance errors.

When it comes to understanding the various circumstances of maintenance errors, i.e. addressing the aspects of human factors in maintenance, then fact finding and reporting becomes more challenging.

To better understand the customer's maintenance operation, Airbus launched in 2006, a maintenance questionnaire specifically dedicated to maintenance personnel.

The objectives of this questionnaire were twofold:

- to obtain up-to-date feedback from maintenance operation; and
- to share the results within the airline maintenance community.

This issue of the Maintenance Briefing Notes will present the summary of the maintenance operations survey.

III Maintenance Operations Survey

A number of randomly selected airlines spread over Western and Eastern Europe have been contacted to participate in this survey, and were provided with a questionnaire specifically designed for maintenance technicians, and for middle maintenance management and supervisors.

Each questionnaire contained about 50 questions, and provisions for free text to add comments or suggestions.

The questionnaire was divided in two main parts:

- the first part covered the subject on most common outcomes of maintenance error occurrences; and,
- the second part was dedicated to organizational cultures, such as reporting systems, transparency, communication, etc.

III.1 Survey coverage and objectives

Part One: Most common Outcome of Maintenance Error Occurrences	
✗	To find out the most common outcomes of maintenance errors in the company
✗	To identify the most likely reason for those outcomes
✗	To identify the most frequent types of maintenance errors
✗	To find out when usually are the errors detected
✗	To find out what does "violation" means for respondents
✗	To find out the most significant reasons for violations
Part Two: Organizational Culture	
✗	To find out why the deviation from the procedures occurs
✗	To find out the level of supervision when accomplishing a task
✗	To identify personnel awareness of the maintenance environment
✗	To find out the importance of reporting and its impact on employees
✗	To find out if the related trainings on human factors in maintenance environment exist within the company

Out of the contacted airlines, about half responded positively and returned the completed questionnaires.

For reasons of confidentiality, the names of the contacted airlines, and their individual replies are not disclosed.

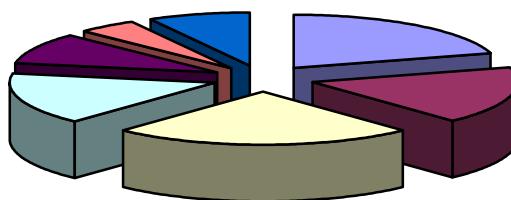
The summary of the replies, as outlined below, are from a limited sample size, and are to be considered as qualitative indicators only. However, they will be complemented by statistical information from other Airbus sources as presented in the section "In-service maintenance event analysis" of this report.

IV Summary of Survey Results

IV.1 Most common outcomes of maintenance errors in the organization

As **Table 1** indicates, the most common outcomes for airline related maintenance occurrence were *part / aircraft damaged during maintenance*. This was followed by *incorrect installation* (orientation of a part) and *incomplete installation*.

Table 1 - The Most Common Outcomes of Maintenance Errors



- Incorrect installation (orientation of part)
- Incomplete installation
- Part/aircraft damaged during maintenance
- Tool lost on aircraft
- Material left on aircraft
- Injury to personnel
- System operated unsafely

Reasons given for *part / aircraft damaged during maintenance* were 'time pressure', followed by 'fatigue', 'shifts hand-over communication problems' and 'environment'.

Incorrect installation or orientation of part was explained by 'time pressure', followed by 'lack of technical knowledge / skills / qualification' and 'inadequate training'.

The most likely reason given for *incomplete installation* was 'time pressure', followed by 'lack of technical knowledge/skills/qualification', 'lack of communication' and 'fatigue'.

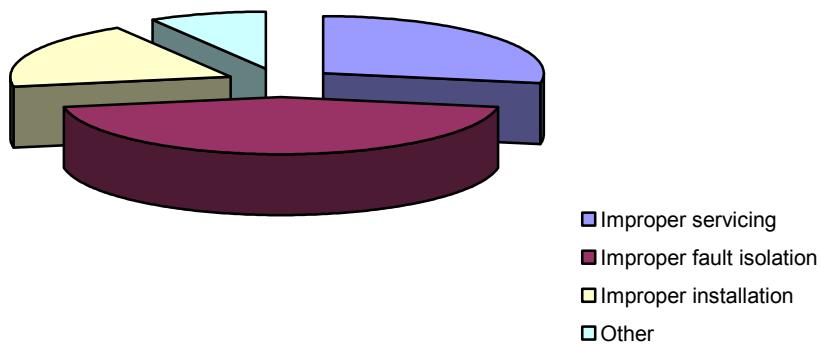
'Time pressure' and 'lack of technical knowledge and skills' were among the most likely reasons for the above occurrences of maintenance errors.

Problems with high workload; the workforce being spread too thinly over the jobs; many interruptions; too little time to do the job, were reported by the respondents to be factors that have to be considered by management at the highest level, as they are the results of 'Pressure'.

IV.2 The most frequent types of errors in maintenance

The most frequent errors, as illustrated in **Table 2**, are '*improper servicing*' (service not performed; system not re-/deactivated; insufficient fluid), '*improper fault isolation*' (system not properly tested; not properly inspected) following by '*improper installation*' (incomplete installation; wrong orientation).

Table 2 - The Most Frequent Types of Errors



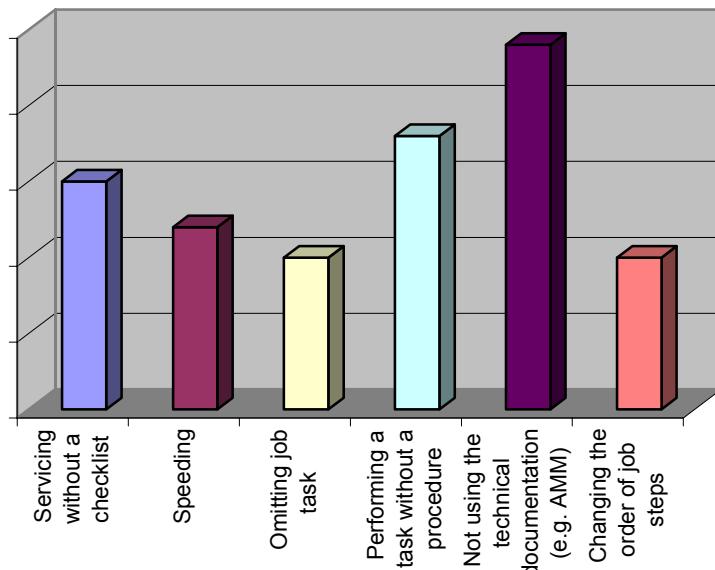
Among other types of errors are '*general improper aircraft maintenance due to economic pressure*', '*incorrect interpretation of maintenance task or technical manuals*', and '*damage of aircraft*'.

In the opinion of those surveyed, as illustrated in **Table 3**, most of them consider '*not using the technical documentation*' (for example the Aircraft Maintenance Manual - AMM) as a violation*.

This is followed by '*performing a maintenance task without a procedure*' and '*servicing without a checklist*'.

* A violation is an intentional deviation from procedures or practices (e.g. non-compliant actions that have become normal, performed necessarily in order to get a job done, etc..).

Table 3 - Perception of violation



The most likely reason for '*not using technical documentation*' are 'it is unavailable', closely followed by 'the job was carried out several times, and became a routine task', and 'the preparation of technical documentation needs more time than the job itself'.

V In-Service Maintenance Events Analysis

As said earlier, the results of the questionnaire are not meant to be of statistical relevance due to its limited number of participating airlines.

However, they can be compared and supported by an analysis using the Airbus In-Service event data base, filtered by those events related to maintenance operations.

For this analysis, an investigation was done on the basis of reports on delays / cancellations, and in-flight turn backs, using a representative time frame, number of airlines, and reports.

The results of this research is presented in **Tables 4 and 5**.

Table 4 - Errors during Maintenance

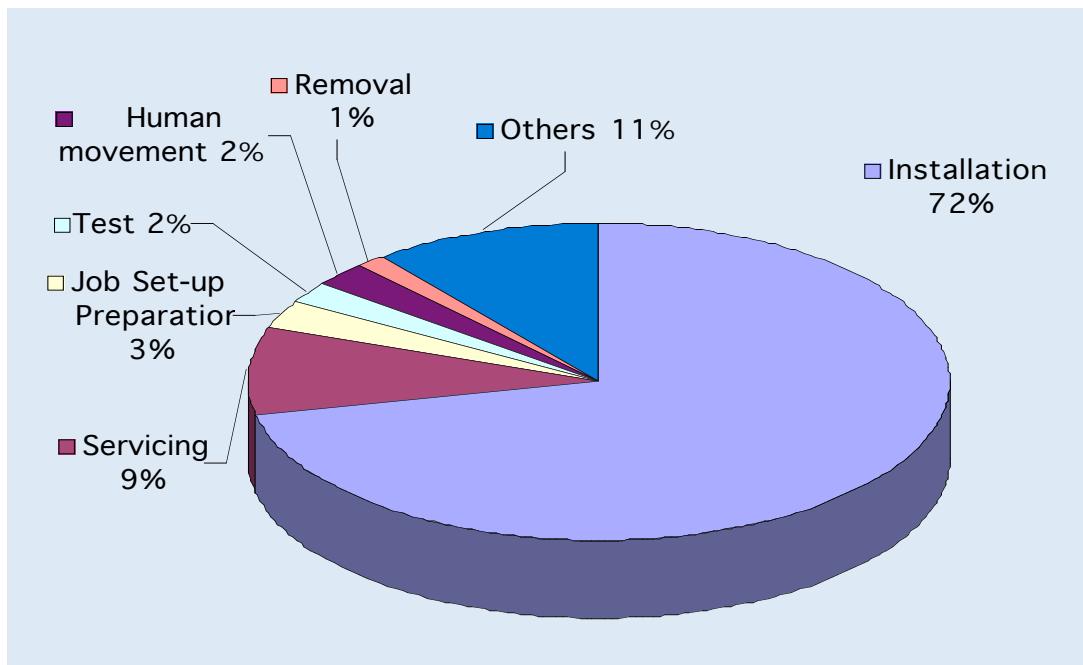
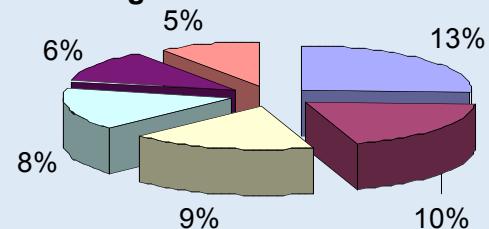


Table 5 - Top-six Error Types during Installation

- Installation- Incomplete- Component installed but not secured
- Installation- Incorrect- Incorrect torque applied
- Installation- Incomplete- Component/ fluid/ material missing
- Installation- Incomplete- Access panel not closed/ secured
- Installation- Incorrect- System/ equipment incorrectly set or re-set
- Installation- Incorrect- Incorrect component/ part/ fluid/ gas/ material installed



VI Synthesis of Survey and Events Analysis

VI.1 Maintenance errors patterns

Although both surveys were done using different methodology and population, the general trend is confirmed that in most instances, maintenance errors were performed during component installation.

This trend was visible throughout all ATA chapters, and follows also the conclusion of other similar aviation research activities.

Within the installation process, and looking at a more detailed activity level, it was found that:

- Installed, but not attached / secured
- Parts missing
- Access panel not closed
- Wrong location of parts

... were the most frequent error types.

VI.2 Organizational culture

A company's culture is one of the significant factors, influencing human performance. Being now more familiar with the outcomes of maintenance errors and their reasons, we will see how the mechanics and their supervisors have perceived reporting and safety concerned issues.

The respondents reported using the authorized procedures referenced in technical data, either always or very often. The mechanics use approved parts or lubricants; however, in some cases, due to lack of spares in stock they use non-approved parts and launch the request to engineering in order to validate the interchangeability. Most of the time maintenance engineers before signing off on job cards pay attention if the task was carefully accomplished, but they also reported that under time pressure one can overlook if the task was completed to sign-off on job cards.

VI.3 Reporting

Respondents were asked about their attitude towards reporting. Most of the mechanics feel comfortable reporting safety problems to their supervisors, and the vast majority of them strongly agree that it is their responsibility to report the errors to their supervisors, regardless of the consequences.

Respondents from managerial levels consider that their mechanics and themselves either always or very often feel comfortable reporting maintenance error problems. However, some responses revealed, that managers occasionally or even fairly often keep information informal instead of using an official channel. One of the possible reasons for

this is 'using an official channel is very complicated'. Most of the respondents preferred not to comment.

VI.4 Impact on reporting

The maintenance technicians were asked to define the possible impacts of reporting.

The impact of reporting seen by the respondents:

- continuing training;
- accountability;
- alerting the people of the possibility the errors being possible;
- avoiding re-occurrence of errors;
- completing written reports to assist safety /quality investigations;
- improving safety;
- learning from the reporting (no blame policy) and adapting procedures and knowledge during trainings;
- loosing a job or getting sidelined; and,
- nothing.

Most of these responses with exception of two last ones confirm positive attitude towards reporting in these companies.

Some of the managers still hope that reporting will lead to the improvement of the maintenance process and will have only positive result; however, very often when reporting the problems 'nothing happens'.

VI.5 Perception of safety by mechanics

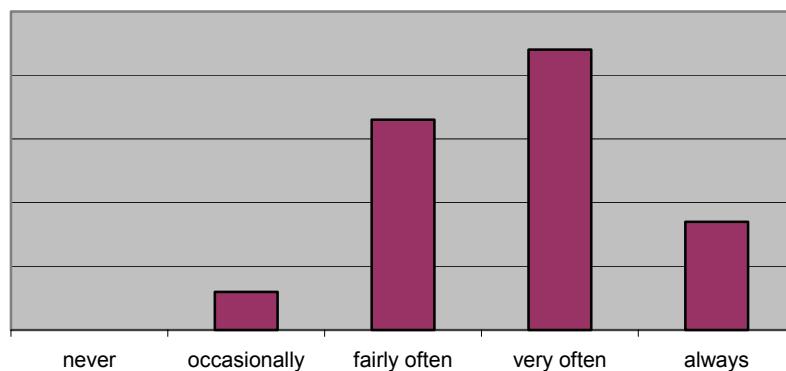
Several questions on the perception of safety were asked to the mechanics.

Either occasionally or fairly often the mechanics deliver instructions on safety procedures to direct reports. Most of the mechanics never feel that the flight safety is compromised to over-productivity. The safety of the personnel plays an important role in their organizations, with the exception of some respondents who occasionally feel that the safety of personnel is compromised in the interest of productivity. Mechanics 'fairly often' feel that senior leadership listen to, and care about safety.

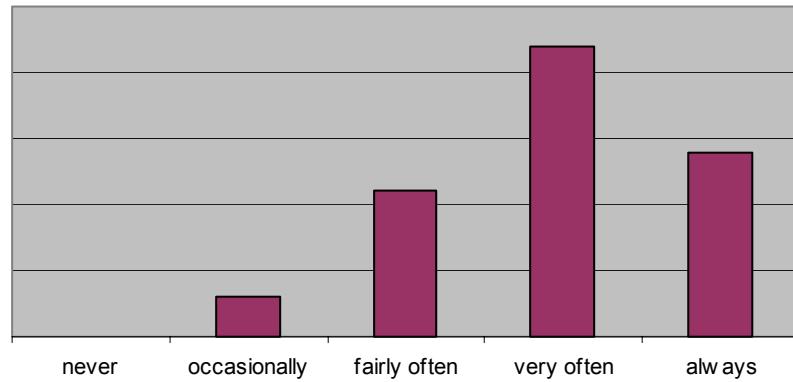
VI.6 Feedback on safety performance

While reporting is in place, feedback might be provided to all the employees concerned in order to improve the safety conditions and reduce error reoccurrence. **Table 6** thru **Table 8**, below, illustrate of how often the participants *receive constructive feedback from their supervisors about their safety performance; receive constructive feedback from the direct reports about their safety performance; and how often they receive positive feedback about their safety performance.*

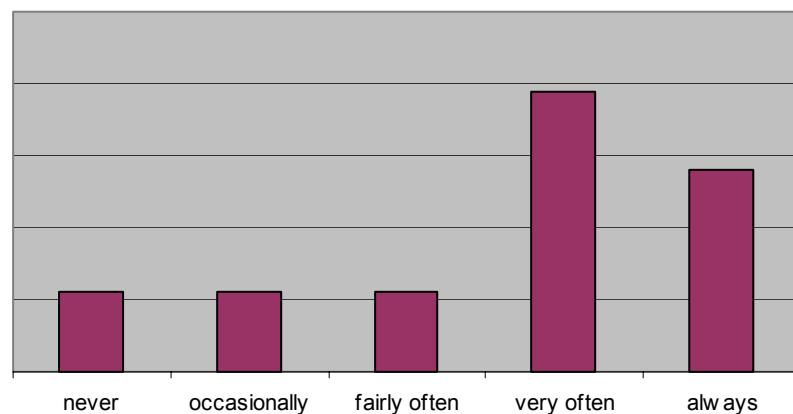
Table 6 - Receice Constructive Feedback From the Supervisor About Safety Performance



**Table 7 - Receive Constructive Feedback
From the Direct Reports About Safety Performance**



**Table 8 - Receive Positive Feedback
About Safety Performance**



VI.7 Training on Human Factors

Most of the mechanics reported to attend Human Factors trainings. Some participated twice a year, others once in two years.

Respondents from the management confirmed to have a Human Factor Program within their companies. It exists between 5 to 10 years, and it improved the management of human factor errors in their organization. They also have training on Human Factor, and training tools are sufficient to manage maintenance errors.

VI.8 Survey free comments

Several participants that were surveyed, provided their comments and suggestions.

Their feedback is presented below, without any order of priority.

Maintenance errors can be managed by ...

- Better communication, training and equipment;
- Developing a good attitude towards following the procedures and identifying a 'bad' or cumbersome procedure for the modification, better organization;
- Human factors evaluation of events involving personnel involved to ensure exact causes are identified;
- Analysing reasons of errors and minimizing the chance of their repetition;
- Making available a more 'easy to use' maintenance manual system;
- Increasing manpower and ground time;
- Providing regular personal feedback;
- Setting up an error and quality awareness program; and
- Talking openly about failures and maintenance errors.

Maintenance personnel working conditions can be improved by ...

- Shift work is a fact of aviation work life. Recognizing that constantly changing sleep schedules (-rest and work patterns) requires continuous monitoring to ensure staff are 'fit'. Work in different weather conditions is also part of aviation work life, the aircraft should be completely parked in well-lit hangars for maintenance and servicing. Tools and equipment, technical documentation must be available without delays, which if not available may cause someone to proceed in haste,
- Shift pattern evaluation to match workload to manpower available,
- Better organizing of shifts and manpower on checks,
- Internal communication and processes could be improved,
- Equalize the different customer procedures and requirements,
- More time - use all safety and check manpower,
- Provide tool facilities and trainings,
- Take into consideration all aspect of human factors; and,
- Maintenance personnel 'have to change attitude and this can only be achieved by means of their appraisals.'

Additional comments and suggestions ...

- Give more detailed access to interchange ability and mod status;
- It is time that engineers put behind them the feeling that managers talk about following safety and procedures for public consumption only, and privately expect them to operate outside of safety and procedures to get the job done;

If the company has a policy on safety and procedures then it should be accepted that this is the policy and engineers should work within this framework only;

I'm sure you wont find management complaining. The most important human factor for this is awareness and communication;

- Human factors training must be provided for all personnel involved in aircraft maintenance before a person starts working on aircraft / systems, e.g. Planning, Engineering, etc;

- Clean the AMM from cautions, warnings and notes like: "Be careful when you drain oil from a hot engine. Hot oil is dangerous. If it touches your body or eyes it will burn badly!"- then the AMM will be read properly again by maintenance staff;
- Job cards, log books and work paper related administrative procedures should be standardized worldwide. It seems that the paperwork on aircraft maintenance becomes more important than the work itself;
- Reduce time pressure;
- Work instruction in the AMM /task cards should be clear defined. In some cases there is too much information in wrong place. Important information is hidden in the text; and,
- Not mentioning errors means you hide these problems, this is not allowed. Making mistakes can happen to everyone. Take the necessary steps and attitude so it won't happen anymore, and more importantly let the other people know what happened, so they can learn from it.

VII Case Study

"Improper closing and securing of access panels" were cited as being amongst the most frequent maintenance errors conducted by the surveys explained above.

One of the most "visible", and probably most expensive consequence of not correctly securing panels, are the number of fan cowl door losses reported after take-off.





The events of fan cowl door losses were reported randomly over the past years, and in every case the post-incident investigations revealed the same findings:

- The cowls were opened for maintenance prior to the flight;
- The cowls were found un-latched and not properly hooked and secured;
- Air scooping after take-off resulted consequently in the cowls separation;
- In each case the aircraft performed an in-flight turn-back followed by a safe landing; and,
- Consequential structural damage further to impact with pylons, slats, flaps, fuselage skin and MLG, was ranging from minor to severe.

A number of modifications were made available, and have been successively introduced into the production line as summarized below:

- Fluorescent paint on the forward cowl door latch handles :
 - V2500: IAE SB V2500-NAC-71-0227
 - CFM: GOODRICH SB RA320071-117

⚠ Ease visibility when not correctly secured

- Caution decal on the outboard fan cowl doors :
 - V2500: IAE SB V2500-NAC-71-0235
 - CFM: GOODRICH SB RA32071-117
- ↳ **Caution note within working area**
- Latch assy modification to ensure that latch handles will hang down if :
 - unlatched: weighted latch and improved anti-swivel plate
 - V2500: IAE SB V2500-NAC-71-0256 and AIRBUS SB A320-71-1028 (AD 2003-18-06)
- ↳ **Improved visibility of an unlocked door**
- Hold open device :
 - V2500: IAE SB V2500-NAC-71-0259 and AIRBUS SB A320-71-1028 (AD 2003-18-06)
- ↳ **Ease detection, e.g. during flight crew visual inspection**
- Installation of new restrainers to prevent improper rotation of the eye-bolt :
 - CFM: GOODRICH SB RA32071-117
- ↳ **“Murphy proof” design concept**
- Installation of improved latch handle hook spring :
 - CFM: GOODRICH SB RA32071-117
- ↳ **Design change**

There are also Standard Operating Procedures (ref. to A318/A319/A320/A321 FCOM Chapter 3.03.05) asking the flight crew members to visually inspect that the fan cowl doors are closed and latched prior to each flight.



However, there are more recent in-service reports about fan cowl door losses, even on modified aircraft, and Standard Operating Procedures in place.

It confirms that the maintenance technicians are the important element in the chain of preventive measures by strictly adhering to the instructions as per AMM 71-13-00 for proper latching and closing of fan cowl doors after each maintenance requiring cowl opening.



VIII Conclusion

The aircraft manufacturer has the privilege of receiving operational information worldwide from a diverse customer base. Sharing such information with our customer is one of the objectives of the Maintenance Briefing Notes.

As one can see, maintenance errors during installation procedures, and securing of components, are one of the most frequent error types.

This is one of the reasons we chose the case study of engine fan cowl losses. It also shows that despite technical modifications and improvements of technical manuals, the human being, i.e. the maintenance technician in our case, is an essential and non-replaceable element in the chain to ensure a safe and cost efficient aircraft operation.

We hope you found this issue interesting and worthwhile, and as mentioned in the preface, we look forward to your comments and feedback, either to <mailto:uwe.eggerling@airbus.com> or <mailto:frank.schreiber@airbus.com>

The next issue of the Maintenance Briefing Notes will be published in the Fall this year.

This Maintenance Briefing Note (MBN) is part of a set of Briefing Notes that provide an overview of the applicable standards, techniques, best practices, human factors, suggested company prevention strategies and personal lines-of-defense related to major threats and hazards that may affect maintenance.

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