

15.0 QUALITY MANAGEMENT SYSTEMS IN AIRCRAFT MAINTENANCE

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INTRODUCTION

This paper differs from all the others at this conference in that the author has little involvement in the air transport industry except that I chaired the JAR (Joint Airworthiness Regulation) 145 Quality Assurance Review Team set up by the CAA-SRG (Civil Aviation Authority - Safety Regulation Group) in 1996/7 as a result of an [AAIB](#) Safety Recommendation. This is, therefore, a view of the industry from outside, from a member of the travelling public.

I suppose that what impressed me most during the Review Team work was:

- The dedication of individuals in aircraft maintenance to the goals of airworthiness. Very rough calculations indicate that for UK operations, a maintenance error leading to an MOR (Mandatory Occurrence Report to the [CAA](#)) occurs about once every 5-10 million working man-hours on aircraft maintenance which equates to 50 or more working careers. Impressive as this is, the CAA believes that the total rate of incidents must improve by a factor of three over the next two decades if the airline accident record is to remain acceptable and part of this improvement must come from maintenance.
- A key problem that the industry appears to have is maintaining the present quality and quantity of the production workforce. It is difficult to attract dedicated young engineers and provide them with the right experience to maintain this quality of workforce.
- Whether or not management admit it or agree, almost all staff at production level believe that the pressures on them are increasing. In more cases than I would have wished, I met production staff who were under a great deal, and probably too much, stress. Where the excellent maintenance performance of the past has depended on people it may or may not be improving at all.
- There seems to be an erosion of the respect for the licenses held by Certifying Engineers. This is a complex subject but it seems to me that the core of the safe and successful operation of UK air transport lies in licensed Engineers and it is perilous to ignore that fact.
- Some maintenance manuals were almost universally stated as being user unfriendly. I was astonished to discover that usability of manuals plays no part in the issue of a [C of A](#). There seems to be enthusiasm amongst many production staff to use computers and I.T. systems for information and this should be resourced by maintenance organizations.

- The vagueness of understanding of the operation of [JAR](#) 145 throughout the industry but most importantly at the Quality Manager and Accountable Manager level.

THE WORK OF THE REVIEW TEAM

The Terms of Reference of the Review Team are given in [Table 15.1](#). The main activities of the Team were to:

- Review the legal framework of [JAR](#) 145: one interesting feature of the review is that relatively few people in the industry seemed to understand the correct relationship between the [CAA](#) and the JAA (Joint Aviation Authority) and at least in part this must be because there is no clear exposition available from CAA and JAA.
- Visit the Accountable Managers and/or the Quality Managers of a number of maintenance organizations working under [JAR](#) 145 (including large international airlines at home and secondary bases, regional airlines, specialist aircraft operators, independent maintenance organizations and component maintenance organizations).
- Have parallel meetings at shop floor level on a confidential basis and with others who have had considerable experience in aircraft maintenance.
- Seek the confidential views of those on production by means of a questionnaire (with room for free ranging comments). This resulted in over 120 responses.
- Obtain certain statistical data on, for example, the age distribution of licensed engineers, the occurrence of maintenance related MOR's (Mandatory Occurrence Reports) and the [CAA](#) resources for supporting UK aircraft maintenance.

The evidence collected from all of these sources (about 400 recorded conversations and written submissions of various forms) provided a coherent view of the state of the industry.

Table 15.1 Terms of Reference
<p>To consider the CAA view that emphasises the importance of an effective and independent Quality Assurance (QA) System in the UK maintenance organizations. The Group should:</p> <p>Review the development of QA systems and their associated requirements in the aircraft maintenance field in the UK, the USA, and at least one other JAA member country.</p> <p>Identify the purpose and value of QA systems and the objectives they meet in aircraft maintenance organizations by comparison with an inspection system.</p> <p>Review the working of a small sample of existing QA systems to evaluate their effectiveness in achieving the objectives in 2 above, and if not why not.</p>

Assess the CAA procedures and available resources for the approval and subsequent monitoring of maintenance organizations focusing on QA systems, in order to judge whether the scope and depth of CAA monitoring is sufficient to ensure compliance with current requirements and procedures.

Propose new or amended requirements and guideline material which would result in more effective QA systems able to meet the objectives in 2 above.

Propose new or amended procedures for the existing JAA requirements and any new or amended material proposed in paragraph 5 above.

SOME EXAMPLE SURVEY AND DATA ANALYSIS RESULTS

A confidential questionnaire was prepared and distributed to those who requested it as a result of advertisements in trade journals and notices. Over 120 responses were received. It must be noted that respondents are self selecting: those who do not have strong views or who believe that the industry requires no change are less likely to respond. However, the discussions held by independent members of the Team at the production level with certified engineers and mechanics (who were not self selecting) very much confirmed the responses to the questionnaire.

A summary of the responses to the questionnaire is as follows for all respondents.

Is pressure and stress on maintenance staff increasing?	Yes	95%
	Sometimes	5%
	No	0%

Do Certifying Engineers understand their responsibility for quality control?	Yes	80%
	No	16%
	No comment	4%

Are standards better today than 10 years ago (Nil responses, where the respondent has less experience, excluded)?	Yes	9%
	No	91%

Is the Hanger Team leader or supervisor able to control the workload or team size allocated to him?	<u>Yes</u>	<u>Sometimes</u>	<u>No</u>
-In the line maintenance environment	9%	40%	51%
-In the base maintenance environment	15%	49%	36%

Do Supervisors and management accept their quality responsibilities?	Yes	37%
	Sometimes	49%
	No	14%

Internal QA audits

	<u>Yes</u>	<u>Sometimes</u>	<u>No</u>	
Notified in advance?	67%	19%		14%

What is your perception of their purpose?		<u>PR</u>	<u>Quality</u>	<u>Punishment</u>
	33%	56%		11%

What kind of discrepancies are found?		<u>Housekeeping</u>	<u>Technical</u>	<u>Both</u>
	45%		16%	39%

Are the right kind of corrective actions taken?		<u>Yes</u>	<u>Sometimes</u>	<u>No</u>
	28%	61%		11%

Where errors have been reported, do management..?		<u>Establish cause</u>	<u>Punish</u>	<u>Both</u>
	44%		44%	12%

Has <u>JAR</u> changed the way..?:		<u>Yes</u>	<u>No</u>
a) Work is performed	36%		64%
b) The way that <u>QA</u> is performed	68%		32%

Respondees were free to add any comments that they would wish: many did. A summary is as follows: (the results are as a percentage though each response may contain more than one comment or no comments).

QA department is only concerned with paperwork **15%**

Commercial pressures are increasing to the detriment of quality **15%**

Company authorizations are being given out too freely **14%**

QA department is not independent of management **10%**

Workload levels are too high: ratio of licensed Engineers to mechanics is too low **10%**

There is too much stress in the job **6%**

QA/CAA audits are a waste of time **4%**

QA only become involved after a event **4%**

QA staff are unqualified **3%**

Human factors training is needed **3%**

The key results are that of those responding:

- 95% feel that pressure and stress is increasing.
- 80% feel that Certifying Engineers understand their responsibility for Quality Control.
- 91% believe that standards are no better today than 10 years ago.
- About half note that the hanger team leader or supervisor does not control workload or team size.
- Most [QA](#) audits are notified in advance.
 - ⇒ Only half are thought to benefit quality of actual maintenance work.
 - ⇒ Less than a third always result in corrective action
- When errors are found, nearly 60% of the cases are thought to result in punishment of individuals.
- I was disturbed by the number of licensed engineers who I interviewed or who wrote to me who described working in a ‘blame’ culture. I was told, for example, that to delay an aircraft departure without a very serious and obvious safety reason was ‘career limiting’. The feelings of those relating these comments to me is undeniable: whether they are justified is, I suggest, not as important as the fact that those working on production genuinely feel to be under threat in some organizations. What concerns me is that there was consistency in the responses within one or two organizations whilst many others appeared to have no staff who felt threatened or likely to be blamed for reporting an error.
- The introduction of [JAR](#)-145 has had much more effect on the way [QA](#) is performed than on the way work is carried out.

In some cases, the results are more usefully analysed by organization. About 75% of the responses came from 6 maintenance organizations, notated A to F in [Tables 15.2 to 15.5](#) below.

Table 15.2 Has training in Human Factors been given to you or to anyone in your team? (Percentage by organization)		
Organization	Yes	No
A	100	-
B	15	85
C	-	100
D	-	100
E	-	100
F	-	100

TOTAL RESPONSE: No.	20	80
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Table 15.3 Are your company procedures..? (Percentage by organization)

Question	...Easy to Understand?			...Used and Followed?		
	Yes	Sometimes	No	Yes	Sometimes	No
A	40	40	20	-	100	-
B	40	40	20	5	85	10
C	100	-	-	50	50	-
D	40	40	20	25	75	-
E	30	30	40	20	60	20
F	40	40	20	40	60	-

Table 15.4 Where errors have been reported, do management..? (Percentage by organization)

Organization	Establish Cause	Punish	Both
A	50	-	50
B	40	40	20
C	20	20	40
D	25	50	25
E	20	70	10
F	60	25	15

Table 15.5 Is the relationship between flight crew and Engineers too distant? (Percentage by organization)

Organization	Yes	No
A	90	10
B	70	30

C	10	90
D	40	60
E	25	75
F	50	50

The Human Factor Occurrences due to both improper installation and improper servicing have been analysed for 1992 to 1996. The results are given in [Table 15.6](#) below.

Year	Improper Servicing	Improper Installation	Total
1992	45	111	156
1993	39	102	141
1994	54	148	201
1995	60	144	204
1996	84	153	237

The age distribution of licensed Engineers as of October 1996 is set out in [Table 15.7](#) below. Note that the [CAA](#) statistics cannot separate those who have U.K. licenses and are employed overseas and those who retain their licenses but no longer use them as part of their employment.

Age	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
% of number	3.3	6.7	13.4	15.9	17.2	13.5	10.6	10.8	5.6	1.8	0.6	0.3	0.2

For example, from these figures, nearly 20% of current licensed Engineers are aged over 55 which, if representative of the numbers of those active in U.K. airline aircraft maintenance, could be an indicator of shortages in years to come.

Finally, some very broad statistics based on the Mandatory Occurrence Reports 1994-97 divided by the average number of aircraft in the fleet during that period and using the same lettering for each company as in previous company-split data are set out below in [Table 15.8](#).

Table 15.8

Company	<u>MOR</u> 's per aircraft over period 1994-7
A	1.3
B	2.0
C	0.4
D	NO ACCURATE FIGURES
E	1.70
F	NO ACCURATE FIGURES
G	1.2
H	2.3

In the case of companies G and H, the number of questionnaires returned and identifiable by company was insufficient to analyse. In looking at those figures it should be noted that high MOR's / Aircraft (i.e. poor) ratios could be due to:

- being lead carrier for new aircraft type.
- having a very open management style and avoiding punishment for disclosure of faults.
- running very short haul routes or specialist aircraft (e.g. helicopters).

That said, in the case of Company B only 5% of questionnaire respondees believed that company procedures are followed and 70% believe that the relationship between flight crew and Engineers is too distant. In the case of Company C (with the best MOR's / aircraft ratio), 100% said that the company procedures were easy to understand and follow, 50% said that they were used (implying all of the time) and 90% accepted the flight crew / Engineer relationship.

In the case of the Human Factor Occurrences involving significant risk, the numbers are judged to be related to maintenance for U.K. registered aircraft:

1995 - 6

1996 - 4

As previously noted, these are very low figures for such a large air transport activity.

THE MAJOR RECOMMENDATIONS

It seems to me that the central requirement for a safety management culture in an organization is that those involved should have respect for organizational infrastructure in which they work. In the contemporary airline environment there is a strong historical positive framework that is clouded by several factors. The first is that there is greater commercial pressure on companies and, through them, on individuals to perform to highly demanding operational requirements. I was concerned, for example, at a very high pressure on some maintenance staff at Heathrow compared with regional airports. Whether or not an airline openly declares the goal of saving money, rising up some league table of punctuality or having the lowest fares, it is clear that the management has to respond to this commercial situation. It seems to me to be a genuinely very difficult task for management to, concurrently, pass down the message that the quality of maintenance must improve so that the rate of [MOR](#)'s due to maintenance decreases and yet improve operational performance. That this has been achieved to date is of great credit to all concerned but continuous extrapolation cannot necessarily be assumed. In particular, there is an increasing pressure in the role of the Accountable Manager, a position which is central to every organization acting in air transport. Surprisingly, we found a number of deficiencies in the regulating framework for Accountable Managers. First, when appointed by a company, the choice of individual cannot be formally challenged by the [CAA](#). Second, there is no requirement for them to have any technical knowledge, skill or qualifications; they do not even have to have a demonstrable knowledge of [JAR-145](#), for example. It seems to me that those working on production must have respect for their Accountable Manager and, as a result, the Team has made a number of recommendations about the requirements of personnel filling this position. This will, for example, require an Accountable Manager to have good technical knowledge.

Whilst it may be an extreme position, I am concerned that in some companies many production staff regard [QA](#) Audits as rather pointless. It is indicative that they do not feel that their Accountable Managers are in contact with their real, high stress, world.

Another factor is the developing role of the Joint Aviation Authority. Throughout the survey, I learnt of the respect that almost everyone in the industry has for the quality of the [CAA](#) Safety Regulation Group Surveyors. I have concern that cost cutting within the CAA could reduce their numbers until their only activity is desk bound, satisfying the bureaucracy of the regulations. Also, there was comment about the ability of the CAA to oversee large organizations as effectively as it does small ones. As important is the issue of their future role under [JAA](#). There seems to be a serious risk that the style of JAA is for greater and more detailed regulation that may diminish the authority and value of the judgement of individual Surveyors. The questionnaire responses suggest that the introduction of [JAR-145](#) has affected the operation of Quality Assurance (and that includes an increase in paperwork) but not had any (beneficial) effect on the production work. At least in part this is because concurrent with the introduction of JAR-145 (but to be fair, not necessarily linked) the [QA](#) departments in many organizations have become remote from production and its issues and problems. Some QA departments have become edifices of the I.T. revolution, which is only really relevant to the airworthiness of aircraft if those systems are also available to production staff. We have made a number of recommendations with respect to the Quality Assurance function in organizations. Yet although there is this disquiet about JAA, most in the industry believe, incorrectly, that JAA is an authority above CAA and that in due course CAA will become the 'agent' of JAA. We even heard one operator who wanted to bypass the CAA and deal directly with JAA on a particular matter.

Another important issue concerns the respect held in the industry of the Aircraft Maintenance License. In an era where 30% of U.K. school leavers go to universities to get degrees (a qualification that gives the recipient letters after their name whatever their subsequent knowledge of the subject studied), there is relatively little incentive for able contemporary young people to study for the licenses that carries none of the cache' of a degree and that can in any case be lost, for many reasons, in later life. This is of no making of anyone in aircraft maintenance.

However, within the industry there has been erosion of the Licensed Engineer's position in several ways, for example by the use of unlicensed mechanics to carry out limited and simple tasks (though it could be noted that this scheme was reported to the Review Team as being generally regarded as valuable and not misused) and by company authorizations of the equivalent of type rating (which has been the subject of rather more criticism). More clearly, there has been a general reduction of support for training and lack of enhanced salaries for those who hold licenses, particularly if not being currently used. Yet the aircraft maintenance license system is actually central to the provision of airworthy maintenance and for it to be effective, license holders must have pride in their possession and those above, below and around them in organizational terms must have respect for the possession of a license. The situation should be seen as exactly parallel to that of aircrew and the ATPL (Air Transport Pilots License).

It concerns me greatly that the pressure to erode the role of the licensed engineer will increase industry-wide over the next few years as a result of the retirements even though [JAR 66](#) is intended to arrest any decline in standards. I have the impression that there is insufficient training and education going on in the aircraft maintenance industry at present. It is simply not acceptable for operators to plan substantial aircraft fleet expansion and yet expect to be able to recruit qualified and experienced maintenance staff from the open labour market. With every airline and maintenance organization expecting to do the same it is obvious that there will soon be no pool. There is a need for industry-wide assessment and if need be, collaborative action in the recruitment, training and education of Licensed engineers.

It might be thought by some outside the industry that the solution to most of these problems might rest with greater regulation, notably in the three areas of hours of working, shift handover and ratio of unlicensed mechanics to licensed engineers in any team or shift. However in my view, such regulation is by its nature complex and tends to inhibit rather than encourage best practice. The Review Team decided against more regulation in these areas, though with respect to working hours it is expected that the U.K. will incorporate the EU Social Chapter soon and that this legislation will place adequate limits on working hours. Respect for the framework of airline maintenance depends on individuals being able to take the right level of personal responsibility and that the whole industry adheres to the best practices available. There are some threats in the Team's report in this area: for example reports of [MOR](#)'s related to maintenance will in future have to include details of the hours worked by those involved prior to the event and the qualifications and workload of the team.

OTHER RECOMMENDATIONS

There are a number of other areas where the Review Team made recommendations. These include:

Aircraft maintenance manuals should be easy to use by production staff. Apparently, the usability of manuals does not form part of the [C. of A.](#) requirement. Given the widespread criticism of some manuals this is unsatisfactory even though operators can and do produce their own job cards summarising the official manuals. One obvious problem is that such card (or I.T.) systems may not pass on to second and subsequent owners of the aircraft.

We found considerable interest in the use of V.D.U. screen-displayed manual information and this does need to be developed for wider use. Given that some aircraft types last for 40 years, it is important to put the maintenance manuals of existing aircraft onto such systems.

The reporting of faults by aircrew to engineering staff can be variable: in part it seems to depend on the respect between the two professions in any particular company. Aircrew must recognise that they have a responsibility to give much relevant information, for example, on the sequence of events and indications that led up to a fault, as possible. Simply writing the epitaph 'u/s' in the log is not usually useful even if it satisfies the letter of the law. The relationship between aircrew and engineers seems to be very variable even within one company from fleet to fleet and station to station. A major improvement would be for uniform upgrading to current best practice.

CONCLUSIONS

To anyone looking at aircraft maintenance for the first time, the dedication to airworthiness is very impressive. The figures for incidents and accidents show a quite amazingly low rate of error amongst the front line staff. However, the pressures that surround the industry appear to be leading to a significant stress level in staff. It will take considerable leadership by those at the top of the industry, both in the operations and regulatory sides, to ensure that the safety record continues to improve.