Ministry of Defence

Air Command Secretariat
Spitfire Block
Headquarters Air Command
Royal Air Force
High Wycombe
Buckinghamshire
HP14 4U

Ref: 2019/05093

[redacted]

29 May 2019

Dear [redacted]

Thank you for your correspondence of the 29 April 2019 requesting the following information:

> *I request a paper and electronic copy of any Noise Assessments conducted on C130K aircraft and any documentation associated with Noise Induced Hearing Loss (NIHL) in aircrew during the period 1995 to 2010.*

I am treating your correspondence as a request for information under the Freedom of Information Act 2000 (FOIA).

A search for the information has now been completed within the Ministry of Defence (MOD) and I can confirm that information in scope of your request is held.

A copy of the 2005 Noise Assessment of RAF Lyneham C130K Aircraft is attached at Annex A and a hard copy has been sent to the postal address provided.

Under Section 16 (Advice and Assistance). The 2005 Noise Assessment of RAF Lyneham C130K Aircraft recommendations were addressed directly through the introduction of Active Noise Reduction headsets for aircrew and rearcrew and the use of earplugs and briefings for crew and passengers. These recommendations remained in force until the aircraft was retired from RAF service in October 2013.

In accordance with the Data Protection Act, under S40(2) of FOIA (third party personal data), information contained within the communications under Annex A is withheld as exempt information. This is an Absolute Exemption and not subject to the Public Interest Test.

If you are not satisfied with this response or you wish to complain about any aspect of the handling of your request, then you should contact us in the first instance at the address above. If informal resolution is not possible and you are still dissatisfied then you may apply for an independent internal review by contacting the Information Rights Compliance team, Ground Floor, MOD Main Building, Whitehall, SW1A 2HB (e-mail CIO-FOI-IR@mod.uk). Please note that any request for an internal review must be made within 40 working days of the date on which the attempt to reach informal resolution has come to an end.

If you remain dissatisfied following an internal review, you may take your complaint to the Information Commissioner under the provisions of Section 50 of the Freedom of Information Act. Please note that the Information Commissioner will not normally investigate your case until the MOD internal process has been completed. The information Commissioner can be contacted at:

Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF. Further details of the role and powers of the Information Commissioner can be found on the Commissioner's website at https://ico.ork.uk/.

Yours sincerely,

Air Command Secretariat

OCCUPATIONAL AND ENVIRONMENTAL MEDICINE WING

NOISE AND VIBRATION DIVISION

Report: OEM/130/05 Dated December 2005

A REPORT ON AN IN-FLIGHT NOISE ASSESSMENT OF RAF LYNEHAM C130K AIRCRAFT CREW DURING TRAINING AND TRANSPORT SORTIES

Approved for publication

W J COKER
Air Commodore
Officer Commanding
Royal Air Force
Centre of Aviation Medicine

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Date

OCCUPATIONAL AND ENVIRONMENTAL MEDICINE WING
NOISE AND VIBRATION DIVISION

ROYAL AIR FORCE CENTRE OF AVIATION MEDICINE

Report No: OEM/130/05

A REPORT ON AN IN-FLIGHT NOISE ASSESSMENT OF RAF LYNEHAM C130K AIRCRAFT CREW DURING TRAINING AND TRANSPORT SORTIES

EXECUTIVE SUMMARY

1. The Noise and Vibration Division of the RAF Centre of Aviation Medicine was tasked to establish the noise exposure of personnel during sorties on board the C130K aircraft of 47 and 70 Squadrons based at RAF Lyneham. The assessment was carried out, for personnel working both within the cockpit of the aircraft and in the rear compartment, during flights in the periods of 13-17 Jun 05 and 27-29 Jun 05.

2. The work was performed under the purview of a tasking instigated by Eng Pol AW and SHEF covering all aircraft types and variants in the RAF Fleet. This task was prompted by the planned implementation into UK legislation of the European Physical Agents (Noise) Directive as the Control of Noise at Work Regulations 2005.

3. The C130K aircraft is used for a wide variety of sorties. These can include, amongst others, transport operations over long distances and paratroop drops. Sorties can be of any length up to 13.5 hours.

4. An $L_{EP,d}$ value of 90 dB(A) was found from the data recorded, based on the most at-risk crewmember monitored, for a worst case 13.5 hour flight, with the addition of one hour of noise exposure to incorporate taxiing periods prior- and post-departure. This level was based on the exposure considered daily and would be the exposure of the crewmember on the day of the sortie only. It should be noted that this assumes that the crewmembers spend the rest of the day in a quiet environment and can therefore be assumed as the time limit from engine start to engine stop, ie their total exposure time.

5. The at-ear noise levels aboard the C130K aircraft exceed the noise levels specified as both action and limit values in both current and forthcoming legislation. Crewmembers flying sorties of even short length (1 hour 29 minutes per day or 7 hours 27 minutes per week) are at risk of Noise Induced Hearing Loss (NIHL).

6. Aircrew operating C130K aircraft should be informed that they are at risk of NIHL and be given training to minimise the risk. A headset offering higher levels of attenuation should be procured, possibly with an Active Noise Reduction capability, although this is secondary to high passive attenuation.

7. Passengers travelling in the rear compartment should be informed that they are at risk of NIHL and be provided with hearing protection. The currently provided Aearo Classic foam earplug offers a suitable level of protection. Earmuff type protectors should be offered to those who request it. The Peltor H10A Earmuff (NSN 4240-99-957-6913) offers comparable levels of protection to the earplug currently used. Training should be given in the correct fitting of both earplugs and earmuffs when issued.

8. Noise levels at the ear must be reduced in order to allow the C130K aircraft to fly sorties of the stated length without the crewmembers being exposed to average levels exceeding the limits defined in the legislation. This can be achieved by reducing the ambient cabin noise and increasing the level of hearing protection offered to the crew.

DISTRIBUTION LIST

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A REPORT ON AN IN-FLIGHT NOISE ASSESSMENT OF RAF LYNEHAM C130K AIRCRAFT CREW DURING TRAINING AND TRANSPORT SORTIES

Author: [redacted]

REFERENCES

A. RAF CAM Tasking Proforma CAM/224/04/02/NVD dated 10 Jun 04.
B. European Directive 2003/10/EC (Physical Agents (Noise) Directive).
C. Statutory Instrument 2005 No 1643. The Control of Noise at Work Regulations 2005.
D. JSP 375 Vol 2 Lft 6.
E. Statutory Instrument 1989 No 1790. Noise at Work Regulations 1989.
F. Controlling Noise at Work, Guidance on The Control of Noise at Work Regulations 2005. Guidance Document L108. Health and Safety Executive 2005.
G. BS EN 24869-1: Acoustics. Hearing Protectors. Sound attenuation of hearing protectors. Subjective method of measurement 1993.

INTRODUCTION

1. The Noise and Vibration Division (NVDiv) of the RAF Centre of Aviation Medicine (RAF CAM) was tasked at Reference A by the Herc 2b2 for Hercules IPT at RAF Wyton to establish the noise exposure of personnel inflight during sorties onboard the C130K aircraft of 47 and 70 Sqns based at RAF Lyneham. The work was performed under the purview of a tasking instigated by Eng Pol AW and SHEF covering all aircraft types and variants in the RAF Fleet, prompted by the planned implementation into UK legislation of the European Physical Agents (Noise) Directive (PA(N)D) (Reference B) as the Control of Noise at Work Regulations 2005 (Reference C).

BACKGROUND

2. The Hercules C130K comes in 2 different versions which differ only in the length of the airframe. The Mk1 is the standard length version and the Mk3 has a cargo area that is approximately 4.5 metres longer. The C130K is a transport aircraft used primarily to carry troops, passengers and freight. Flights can vary greatly in length with a range of profiles possible, for example:

a. Transport flights where the aircraft will take off, cruise at a constant altitude and then land.

b. Manoeuvre and circuit training (MCT) flights where the aircraft will perform landings and rollers in different configurations for a period of time.

c. Paratroop/parawedge flights where the aircraft will drop parachutists and/or cargo at a range of speeds and altitudes.

3. The aircrew of a C130K consists of 2 pilots, a flight engineer, a navigator and a loadmaster. The loadmaster has no dedicated workstation and will spend time between the rear of the aircraft and the cockpit as required. Seating is also provided for 3 spare crew members at the rear of the cockpit. The cargo area is configurable depending upon what the aircraft is required to carry. The Mk1 can carry up to 92 passengers; the Mk3 can carry up to 128 passengers. Passenger seating consists of webbing straps attached to a tubular frame. The seating can be located along both sides of the cargo area and/or down the centreline of the cargo bay. Annex A shows a diagram of the seating.

4. Hearing protection for the aircrew consists of Racal Atlantic communication headsets (NSN 5965-99-786-9796). These are used to monitor internal and external communications channels. Passengers are issued with Aearo Classic earplugs (NSN 6515-00-126-3570).

RELEVANT STANDARDS

5. The occupational noise exposure of crew personnel is to be assessed in accordance with Reference D. Reference D is based on the current Noise at Work Regulations 1989, detailed at Reference E. In order to prevent noise induced hearing loss (NIHL), Reference D sets a number of action levels. The First Action Level (FAL) is set at an 8-hour daily personal exposure level ($L_{EP,d}$) of 85 dB(A), the Second Action Level (SAL) at an $L_{EP,d}$ of 90dB(A) and the Peak Action Level is set at a C-weighted instantaneous Sound Pressure Level (L_{Cpk}) of 140 dB(C).

6. The new PA(N)D sets new action and limit values for daily exposure to noise. This directive will be implemented into UK law by 6 Apr 06, as the Control of Noise at Work Regulations 2005 (CNWR) at Reference C. The CNWR defines a Lower Exposure Action Value (LEAV) for continuous noise at an $L_{EP,d}$ of 80dB(A), an Upper Exposure Action Value (UEAV) for continuous noise at an $L_{EP,d}$ of 85 dB(A) and an Exposure Limit Value (ELV) at an $L_{EP,d}$ of 87 dB(A). The use of a 40-hour weekly noise exposure level ($L_{EP,w}$) is also defined. For impulse (peak) noise, the LEAV is set at an L_{Cpk} of 135 dB(C), the UEAV is set at an L_{Cpk} of 137dB(C) and the ELV is set at an L_{Cpk} of 140 dB(C). For both continuous and impulse noise, the ELV includes the effect of hearing protection. Reference F provides detailed guidance on the CNWR. Transport aircraft do not produce peak noise and therefore peak noise measurements were not made.

ASSESSMENT PROCEDURE

7. Measurements were made during a number of flights flying from RAF Lyneham. Table 1 shows the details of the flights made.

Table 1 - Details of Flights During Which Noise Measurements Were Made

Date	Tail Number	From	To	Duration (hh:mm)	Type of Flight
13 Jun 05	XB299	1950	2110	1:20	Manoeuvres and Circuit Training (MCT)
14 Jun 05	XV220	1950	2050	1:00	MCT
16 Jun 05	XV217	1330	1440	1:10	MCT
17 Jun 05	XV220	1100	1400	3:00	Parawedge
27 Jun 05	XV199	1540	1910	3:30	Instrument rating test profile (Conversion Training Flight (CTF))
28 Jun 05	XV199	1510	1840	3:30	CTF
29 Jun 05	XV199	2140	0040	3:00	MCT

8. All noise monitoring equipment was calibrated both before and after measurements using a Brüel & Kjær (B&K) Type 4231 Acoustic Calibrator which produces reference tones of 94dB and 114dB at a frequency of 1kHz and is traceable to and comparable with, a UKAS reference standard.

9. On boarding the aircraft NVDiv fitted a sample of crew personnel with a Knowles 1785 miniature microphone at each ear (under the headset) attached to a Sony PCM-M1 digital audio tape (DAT) recorder, to monitor the at-ear noise exposure. NVDiv personnel were then instructed to take their seats for take-off and climb to cruise altitude. The monitoring equipment remained in place with each crewmember for long enough that a representative sample of noise was obtained (minimum 15 minutes duration).

10. As soon as permission was given for NVDiv personnel to move around the cabin NVDiv team members shadowed the monitored crew with B&K 2260 Sound Level Meters (SLM) to give noise levels external to the headsets worn. Measurement positions were recorded in terms of seat number at which the monitored personnel were working. Measurements were also taken with the B&K 2260 at the ear positions of the passenger seating in the rear of the aircraft. These measurements were also recorded in terms of seat number. A plan of the aircraft can be seen at Annex A.

11. Once a representative sample of noise exposure was obtained at each position, the noise monitoring equipment was rotated through the crew. Measurements were undertaken for as many cockpit and rear cabin personnel as was possible within the constraints of time and crew training requirements.

ANALYSIS

12. The noise data were analysed using dedicated 01dB dBTrait and B&K Evaluator software. The data was used in conjunction with information on working practices discussed with the aircrew to determine $L_{EP,d}$ values attributable to the aircrew. An $L_{EP,d}$ to which a crewmember can expect to be exposed when working on the aircraft for a worst case (13.5 hour) period in a single day was calculated in terms of the current legislation (References D and E) and the forthcoming legislation (Reference C). The period of time in each working day that a crewmember can fly was also calculated, up to the action and limit values of the current and forthcoming legislation.

13. The forthcoming legislation also allows the full working week to be taken into

account. As it is unlikely each crew will fly daily, calculation of $L_{EP,w}$ based on weekly flying hours will reduce their noise exposures. The calculation has been performed, based on measured levels, to ascertain how many flying hours each crewmember can fly within the space of one 40-hour 7-day week before reaching the action and limit values specified in the forthcoming legislation.

14. As all crew positions are in use whenever the C130K aircraft is in-flight it was decided that the single $L_{EP,d}$ value for the aircraft crew would be based on the crewmember having the highest at ear noise level. The values are therefore based on the noise exposure of the most at risk member of the crew.

15. The passive insertion loss of the Atlantic headset was also calculated using data recorded at the ear during a period in which no communications noise was present in conjunction with the ambient noise measured at that working position. It should be noted that insertion loss measured in this way is not equivalent to attenuation measured in accordance with Reference G, as it does not take into account the Acoustic Transfer Function of the individual ear. To be compliant with current legislation, figures for exposure are calculated using a correction of 1 standard deviation (s.d.) in attenuation figures for hearing protectors (Reference G). The use of a 1 s.d. correction to mean attenuation values means that quoted attenuation figures protect 68% of the population, rather than only 50% which would be the case if only the mean value were used.

16. Measured at-ear noise values with and without contribution from the communications system were used to calculate the Signal-to-Noise Ratio (SNR) each crewmember was using during the flights. This indicates the level of the communication signals above the background noise being selected by the crewmember.

17. Passenger noise exposure was calculated for each seating position in the rear cabin in terms of unprotected and protected at ear L_{Aeq} values for the measurement period. Protected L_{Aeq} values were calculated using manufacturer's figures for the attenuation of the Aearo Classic foam earplug, as made available to passengers. The worst case protected L_{Aeq} was then used to calculate time limits for daily flying to reach the legislative limits.

18. The working week ($L_{EP,w}$) calculation has also been carried out for passenger noise as ground crew could fly in these seats on more than one day in any working week.

RESULTS

19. A numbered seating plan for the aircraft is given at Figure 1, Annex A.

20. L_{Aeq} values measured on the aircraft and the measurement durations are given at Annex B for the noise at the ear with and without communications, the ambient noise in the cabin just outside the headset of the subject and the calculated communications SNR of each measurement, for each flight.

21. The $L_{EP,d}$ value for a worst case 13.5 hour flying day found from the data recorded, based on the most at-risk crew-member monitored, was 89.6 dB(A). This level was based on the exposure considered daily and would be the exposure of the crewmember on the day of the sortie only, for the period of flight only. The addition of one hour of noise exposure to

incorporate taxiing periods prior- and post-departure increases this level to 90 dB(A). Calculations were based on the crewmember having the highest at ear noise level of 87.3 dB(A) measured for the right-hand pilot (see Annex A) during cruise flight conditions measured onboard the sortie on 27 Jun 05 (Annex B, Table 5). The value was therefore based on the noise exposure of the most at risk member of the crew.

22. Table 2 contains the maximum daily exposure times before the action and limit values in the forthcoming legislation would be reached. An $L_{EP,d}$ of 85 dB(A) represents both the FAL of the current legislation and the UEAV of the forthcoming legislation. Calculations were based on the crewmember having the highest at ear noise level of 87.3 dB(A).

Table 2 – Maximum Daily Exposure Times Before Action and Limit Values are Reached.

$L_{EP,d}$ Level in dB(A)	80*	85**	87*
Allowable Time Period of Exposure (hh:mm)	01:29	04:42	07:27

* Forthcoming Legislation
** Current and Forthcoming Legislation

23. Reference C also allows noise exposure to be averaged over a 40-hour working week. It is intended to allow for situations where noise exposure varies significantly day-to-day. Table 3 contains the maximum daily exposure times before the action and limit values in the forthcoming legislation would be reached. The weekly average does not apply to the current legislation.

Table 3 - Maximum Weekly Exposure Times Before Action and Limit Values are Reached.

$L_{EP,w}$ Level in dB(A)	80	85	87
Allowable Time Period of Exposure (hh:mm)	07:26	23:33	37:19

24. Octave band insertion loss figures for the Racal Atlantic Communications Headset, averaged over all crews monitored, are given at Annex C, Table 1.

25. Ambient noise levels measured for the passenger seating to the sides of the cargo compartment are shown at Annex D, Figure 1. Seat numbers are given from the front of the aircraft backward. Tables 1, 2 and 3 give the numerical data for the ambient noise and the calculated protected level to which each passenger would be exposed in that seat, based on the manufacturer supplied attenuation figures for the Aearo Classic foam earplug. The worst case exposure is an ambient L_{Aeq} of 97.8 dB(A), corresponding to a protected level of 73.3 dB(A). For this protected level, ie with correctly fitted Aearo Classic foam earplugs, there are no flying time restrictions either daily or weekly for rear seat passengers.

DISCUSSION

26. The levels of noise exposure are calculated for the worst case, i.e. that of the crewmember having the highest at-ear noise levels measured during the monitored flights. This has been done as the legislation which drives this noise survey requires assessments to be person specific, rather than job specific, and to take into account the fit of hearing protection etc. Under normal circumstances this could be circumvented by measuring a large sample of persons doing a particular task, generating a mean and using a correction of 2 standard deviations about the mean to include 95% of the populace in the stated noise dose figure. Where only a small sample of people is available, Reference F states that the noisiest periods of the worst-case exposed person should be used for the assessment.

27. The results calculated for the aircraft are in excess of the noise levels recommended in both the current and forthcoming legislation, leading to reduced sortie lengths being advised when flying is considered daily (Table 2, above). The ELV of 87 dB(A), specified in the forthcoming legislation, would be reached in 7 hours 27 minutes of flight, therefore limiting the daily range of the aircraft to those destinations which can be reached in that time. It should be noted that this assumes that the crewmembers spend the rest of the day in a quiet environment and can therefore be assumed as the time limit from engine start to engine stop, ie their total exposure time. In practice these time limits are unworkable given the nature of the task for which the C130K is intended. If exposure is averaged over the 40-hour working week the time limits are less restrictive (see Table 3) allowing longer flights daily as long as the total weekly (7-day) exposure hours do not exceed 37 hours and 19 minutes. Weekly flying hours of 7 hours and 26 minutes breach the LEAV and of 23 hours and 33 minutes the UEAV of the forthcoming legislation (the 85dB(A) UEAV also corresponds to the FAL of the current legislation). These exposure times can be regularly exceeded by C130K flight crews. Therefore some noise mitigation is necessary in order to protect crewmembers aboard this aircraft from NIHL when flying transport sorties.

28. The table at Annex B gives L_{Aeq} values for the personnel monitored showing their protected levels without communications (ie, measured with the headset transmitting no signal from the communications system). As can be seen at Annex B, in some cases the attenuation provided by the headset is not sufficient to reduce the at-ear L_{Aeq} to below the 80 dB(A) LEAV of the forthcoming legislation.

29. The communications SNR is a major factor in the overall $L_{EP,d}$ of C130K crewmembers. The communications SNR measured across all flights ranged from 3.1 to 14.3 dB(A). It should be noted that a SNR of 10dB(A) is the accepted requirement for intelligible speech communications. Measured levels above this may be due to poor quality of the communications system, faint and garbled signals being deciphered and/or poor training of crew in terms of the use of the communications system. It should also be noted that in most cases an SNR of 10dB(A) applied to the protected L_{Aeq} without comms values given at Annex B would lead to a breach of at least the LEAV of the forthcoming legislation. For this reason it would be desirable to reduce the attenuated at-ear noise levels significantly to allow the addition of a communications signal without breaching the 80dB(A) and 85dB(A) action values and the 87dB(A) limit value of the forthcoming legislation.

30. Ambient noise levels in the rear cargo compartment seating positions, given at Annex D, are high. It is inadvisable for any personnel to be in this area without hearing protection as they would be at risk of NIHL and passengers should be informed of this prior to engine start. The currently provided hearing protection of Aearo Classic foam earplugs (NSN: 6515-00-126-3570) offers a suitable level of protection, if worn for the duration of the flight, to enable flights of 13.5 hours to be undertaken. Passengers given Aearo Classic Foam earplugs should be shown how to insert them properly prior to engine start. It is often assumed that personnel are capable of fitting this type of hearing protection without instruction. This is usually NOT the case. Some personnel find the use of these earplugs uncomfortable and, given the high ambient noise levels, an alternative earmuff type hearing protector (for example the Peltor H10 (NSN: 4240-99-957-6913), which offers a similar level of protection to the earplug) should be made available. Figure 1 at Annex D shows that there is no particular trend in the distribution of noise levels within the rear cabin. It should be noted that these results may be affected by the size and type of cargo due to shielding and reflection effects differing from those encountered on the monitored flights.

31. Although the LEAV and UEAV of the forthcoming legislation can be exceeded, the requirement is for action to be taken. The ELV of 87dB(A) cannot legally be exceeded. Actions required by employers exceeding the LEAV and UEAV to protect employees are detailed in the forthcoming legislation. The Control of Noise at Work Regulations 2005 state; "*If any employee is likely to be exposed to noise at or above an upper exposure action value, the employer shall reduce risk to a minimum by establishing and implementing a programmeme of organisational and technical measures, excluding the provision of personal hearing protectors, which is appropriate to the activity and consistent with the risk assessment, and shall include consideration of:*

(a) Other working methods which eliminate or reduce exposure to noise;

(b) Choice of appropriate work equipment emitting the least possible noise, taking account of the work to be done;

(c) The design and layout of workplaces, work stations and rest facilities;

(d) Suitable and sufficient information and training for employees, such that work equipment may be used correctly, in order to minimise their exposure to noise;

(e) Reduction of noise by technical means including:

(i) In the case of airborne noise the use of shields, enclosures and sound absorbent coverings; and

(ii) In the case of structure-borne noise by damping and isolation;

(f) Appropriate maintenance programmemes for work equipment, the workplace and workplace systems;

(g) Limitation of the duration and intensity of exposure to noise; and

(h) Appropriate work schedules with adequate rest periods."

32. According to the forthcoming legislation the employer shall only resort to the provision of hearing protection if the above measures are unsuccessful in reducing the noise levels to below the UEAV. If the ELV is exceeded the employer must reduce the exposure to below the limit value.

33. The 3-stage process of controlling excessive noise exposure of employees is defined at Reference E. This details the preferred order in which noise attenuating measures should be taken. It is stated that the noise should first be controlled at source, meaning steps should be undertaken to reduce the unwanted noise being generated from the process. The second stage is to control noise in the path between the source and employee, usually involving barriers, absorbent materials and separation of the source and employee. The third and least preferred stage involves issuing suitable Personal Protective Equipment (PPE) to employees exposed to noise.

34. As it is unlikely to be possible to significantly reduce the noise at source, given that this would be the engine noise and airflow noise over the airframe, the ideal method of reducing the at-ear noise would be to reduce the ambient noise levels in the flight deck and rear compartment of the C130K. Several approaches would be feasible given current and proposed technologies. Noise insulating and absorptive materials could be considered as cladding for hard console surfaces and the interior of the aircraft fuselage as a means of reducing noise levels. Given that weight is at a premium on board the aircraft, effective incorporation of enough of these materials to reduce the noise levels would be difficult. Companies such as QinetiQ would be able to give advice and perform research into the feasibility of this approach. NVDiv can advise on suitable companies and act as subject matter experts on behalf of the Hercules IPT if required. These materials are also under constant development and a programme of 'technology watching' should be implemented.

35. Research has been conducted into Volumetric Active Noise Cancellation (ANC) within aircraft fuselages using a matrix of microphones and speakers to produce destructive interference and reduce noise levels. This technology is in its infancy and would be prohibitively expensive to implement at present, but should be incorporated into a programme of 'technology watching' for future aircraft upgrades. Companies such as QinetiQ are undertaking research into this approach and NVDiv is available to advise the Hercules IPT as subject matter experts.

36. Cabin noise sources should be minimised as much as is feasible. Most of the internal noise sources are a product of a combination of engine noise transmitted through the airframe and air-conditioning equipment. Other noise sources include other equipment located behind the cockpit at the front of the rear cabin. Consideration should be given to the silencing of airflow where it flows into the cabin. This approach should be taken for new equipment fits and upgrades as well as considered for current equipment. There are companies which specialise in techniques and equipment for the reduction of airflow noise and, again, NVDiv can advise on suitability.

37. It is accepted that during operational use it may be necessary to use an undesirably high SNR in order to achieve speech intelligibility where poor quality incoming signals are being received. For this reason it is not suggested that the communications system be fitted with gain limiters. However, the implementation of a warning light on each console, activated by the use of a SNR above 12dB(A), is recommended. This would allow the

radio to be aware that undesirable levels were being used and the situation could be corrected if necessary during routine or training sorties.

38. High communications SNR levels can be a product of poor quality audio, such as high levels of static and feedback, or interference. The communications system fitted to each of the aircraft should be regularly tested for these faults and repaired if necessary. The implementation of selectable electronic filters into the communications system should be considered to improve the quality of the audio. For instance a 'bandpass' filter specific to voice communication frequencies accepted to be necessary for clear speech intelligibility, 300 Hz to 5000 Hz, would be effective in reducing exposure to unnecessary signals and system noise when monitoring speech. Monitoring of other audio signals could also be filtered to the necessary frequencies in this way. Quality of the reproduced signal should be a consideration when any upgrades to the communications system are undertaken.

39. The headsets currently worn by the crewmembers should be reviewed in favour of a hearing protector with a higher attenuation to minimise unwanted noise at the ear. The highest attenuation hearing protector with a communications facility available should be procured as soon as possible. The fitting of Active Noise Reduction (ANR) systems to the hearing protector chosen should also be investigated; however this is a secondary consideration to high passive attenuation.

40. Concerned aircrew should be advised to wear dual protection of Aero Classic foam earplugs (NSN 6515-99-126-3570) beneath their headsets. This will give further protection from ambient noise levels. The communications volume can be adjusted to give a suitable SNR over the protection of the earplug. It is accepted that this solution may cause some discomfort and is suggested as an interim measure prior to the procurement of a superior headset, for flights of extended duration.

41. As stated above, the ELV of 87 dB(A) cannot legally be exceeded unless an exemption certificate is granted. The aircraft IPT Leader is responsible for this and must submit a safety case to the Secretary of State for Defence to obtain the exemption. The procedure for obtaining an exemption will be defined in the updated version of Reference D. An exemption will only be granted if noise exposure has been reduced to as low a level as is reasonably practicable.

CONCLUSIONS

42. The at-ear noise levels aboard the C130K aircraft are too high in terms of both current legislation (References D and E) and forthcoming legislation (References B and C). Crewmembers flying sorties with total exposure times exceeding the periods of time given at Tables 2 and 3 are at risk of NIHL.

43. Although it may be possible to operate the C130K without exceeding the weekly averaged ELV of the forthcoming legislation by ensuring crew are exposed to less than 37 hours and 19 minutes per week, the weekly action values and daily action and limit values may still be breached. Therefore to comply with employer responsibilities in the legislation noise levels at the ear must be reduced in order to allow the C130K aircraft to fly sorties of the stated length without the crewmembers being exposed to average levels exceeding those defined in the legislation. This can be achieved by reducing the ambient cabin noise and increasing the level of hearing protection offered to the crew.

44. Excessive communications SNR values found for a proportion of the crew indicate that there is a need to introduce training in the use of the communications system so that it can be assured only the minimum SNR necessary to the task is used. Problems of excessive noise and feedback in the communications system may also be indicated by high SNR values.

45. Aearo Classic Foam Earplugs (NSN 6515-99-126-3570) are currently issued to passengers as a comfort measure and to facilitate sleep. As passengers in the rear of the aircraft are at risk of NIHL they should therefore be issued hearing protection as a necessity. An earmuff type-hearing protector should be offered as an alternative to the earplug currently available to those people who prefer them. The Peltor H10A Earmuff (NSN 4240-99-957-6913) offers comparable levels of protection to the earplug currently used. Passengers should be informed of the risk and instructed in the correct use of the issued hearing protection.

RECOMMENDATIONS

46. As a result of this work it is recommended that:

a. A headset offering a higher level of attenuation be investigated and procured. It may be possible to upgrade the current headset to offer higher levels of protection and this should be considered with other available competitors.

b. Crewmembers should be informed they are at risk of NIHL and offered the use of Aero Classic foam earplugs (NSN 6515-99-126-3570) beneath their headsets/ helmets.

c. The aircraft crews should be given information on the causes and effects of NIHL and how to minimise the risks in their working environment.

d. Passengers travelling in the rear compartment should be informed that they are at risk of NIHL and provided with hearing protection. The currently provided Aearo Classic foam earplug (NSN 6515-99-12-3570) offers a suitable level of protection. Earmuff type protectors should be offered to those who request it. The Peltor H10A Earmuff (NSN 4240-99-957-6913) offers comparable levels of protection to the earplug currently used. Training should be given in the correct fitting of both earplugs and earmuffs when issued. As the earmuff is issued on loan, a method of cleaning it should also be made available, such as individual anti-bacterial wipes to allow the user to clean the skin-contact areas before use.

e. Future modification to the aircraft (for example, additional external antennae, engine upgrades, interior equipment upgrades etc) should be performed with interior noise levels as a constraining factor.

47. Further consideration is recommended to:

a. Fitment of warning lights to each console to make the crewmember aware that excessive SNR levels are being used.

b. Modification to the communications system to include adjustable filters and bandpass filters to improve the quality of the audio and minimise the unnecessary frequencies to which crewmembers are exposed.

c. Implement technology watching in areas discussed above in order to be aware when other applicable techniques for noise reduction reach maturity.

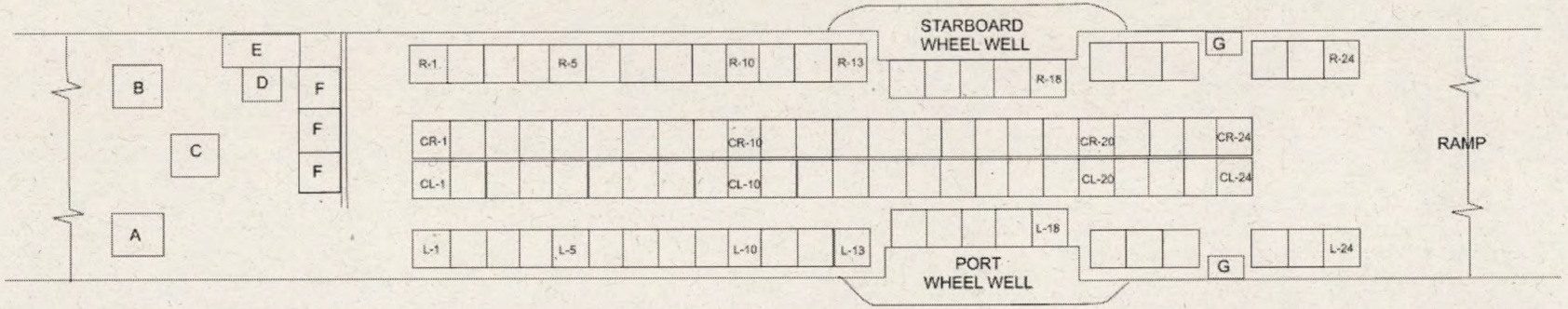
ACKNOWLEDGEMENTS

48. The NVDiv of the RAF CAM would like to acknowledge the assistance of [redacted] (Herc 2b2) at RAF Wyton and the personnel of 47 and 70 Sqns at RAF Lyneham.

ANNEX A TO
OEM/130/05
DATED DEC 05

AIRCRAFT LAYOUT AND SEATING

Figure 1: Diagram Showing Aircraft Layout And Seating



KEY

A - Left-hand Pilot
B - Right-hand Pilot
C - Air Engineer
D - Navigator
E - Navigator Working Station
F - Spare Cockpit Seating
G - Paratroop Door

R - Right-hand
CR - Centre Right-hand
L - Left-hand
CL - Centre Left-hand

ANNEX B TO
OEM/130/05
DATED DEC 05

MEASURED NOISE DATA

Table 1 - Measured Aircrew Noise Data Acquired During Manoeuvres and Circuits Training Sortie on 13 Jun 05

	At Ear Data				Ambient Noise Data			
Position	**L_{Aeq} With Comms/dB(A)**	**Duration of Measurement/ hh:mm:ss**	**L_{Aeq} Without Comms/dB(A)**	**Duration of Measurement/ mm:ss**	**L_{Aeq} /dB(A)**	**Duration of Measurement/ mm:ss**	**Comms SNR (dB)**	**Manoeuvre**
Navigator	77.5	01:30:00	70.9	00:46	82.5	00:33	6.6	Circuits
Flight Engineer	85.2	00:30:00	75.5	00:30	82.3	00:30	9.7	Circuits
Right-hand Pilot	84.0	00:40:00	76.3	01:00	83.4	01:01	7.7	Circuits
Loadmaster	84.7	00:50:00	68.5	01:00	87.3	00:35	4.8	Circuits
Cockpit Spare Seat	85.4	01:36:00	74.0	01:09	82.3	00:30	11.4	Circuits

Table 2 - Measured Aircrew Noise Data Acquired During Manoeuvres and Circuits Training Sortie on 14 Jun 05

	At Ear Data				Ambient Noise Data			
Position	**L_{Aeq} With Comms/dB(A)**	**Duration of Measurement/ hh:mm:ss**	**L_{Aeq} Without Comms/dB(A)**	**Duration of Measurement/ mm:ss**	**L_{Aeq} /dB(A)**	**Duration of Measurement/ mm:ss**	**Comms SNR (dB)**	**Maneouvre**
Left-hand Pilot	81.6	01:30:37	75.9	02:06	81.1	01:01	5.7	Circuits
Navigator	79.5	01:30:50	65.2	00:59	85.6	01:01	14.3	Circuits
Right-hand Pilot	80.8	01:23:33	71.2	02:20	83.4	01:01	9.6	Circuits
Flight Engineer	82.7	01:28:24	77.9	02:20	82.3	00:30	4.8	Circuits
Loadmaster	84.1	01:23:33	79.3	02:20	93.2	00:31	4.8	Circuits

Table 3 - Measured Aircrew Noise Data Acquired During Manoeuvres and Circuits Training Sortie on 16 Jun 05

	At Ear Data				Ambient Noise Data			
Position	**L_{Aeq} With Comms/dB(A)**	**Duration of Measurement/ hh:mm:ss**	**L_{Aeq} Without Comms/dB(A)**	**Duration of Measurement/ mm:ss**	**L_{Aeq} /dB(A)**	**Duration of Measurement/ mm:ss**	**Comms SNR (dB)**	**Maneouvre**
Right-hand Pilot	80.8	01:36:24	71.2	01:48	83.4	01:01	9.6	Circuits
Loadmaster	79.5	01:26:25	75.0	01:39	82.5	00:33	4.5	Circuits
Flight Engineer	84.2	01:34:10	75.4	02:09	82.3	00:30	8.8	Circuits
Navigator	82.8	01:27:39	70.5	00:54	85.6	01:01	12.3	Circuits
Left-hand Pilot	79.3	01:43:23	69.5	02:22	81.1	01:01	9.9	Circuits

Table 4 - Measured Aircrew Noise Data Acquired During Manoeuvres and Circuits Training Sortie on 17 Jun 05

	At Ear Data				Ambient Noise Data			
Position	**L_{Aeq} With Comms/dB(A)**	**Duration of Measurement/ hh:mm:ss**	**L_{Aeq} Without Comms/dB(A)**	**Duration of Measurement/ mm:ss**	**L_{Aeq} /dB(A)**	**Duration of Measurement/ mm:ss**	**Comms SNR (dB)**	**Maneouvre**
Loadmaster	84.1	01:00:01	76.7	01:00	93.2	00:31	7.4	Circuits
Flight Engineer	82.3	01:59:03	72.4	01:18	82.3	00:30	10.0	Circuits
2nd Loadmaster	78.7	00:46:00	73.8	00:30	93.2	00:31	4.9	Circuits

Table 5 - Measured Aircrew Noise Data Acquired During Conversion Training Sortie on 27 Jun 05

	At Ear Data				Ambient Noise Data			
Position	L_{Aeq} With Comms/dB(A)	Duration of Measurement/ hh:mm:ss	L_{Aeq} Without Comms/dB(A)	Duration of Measurement/ mm:ss	L_{Aeq} /dB(A)	Duration of Measurement/ mm:ss	Comms SNR (dB)	Maneouvre
Flight Engineer	83.5	02:00:02	78.8	01:29	82.3	00:30	4.8	Cruise
Navigator	84.4	02:00:51	77.3	00:58	85.6	01:01	7.1	Cruise
Right-hand Pilot	87.3	01:59:20	80.3	00:56	83.4	01:01	7.0	Cruise

Table 6 - Measured Aircrew Noise Data Acquired During Conversion Training Sortie on 28 Jun 05

	At Ear Data				Ambient Noise Data			
Position	L_{Aeq} With Comms/dB(A)	Duration of Measurement/ hh:mm:ss	L_{Aeq} Without Comms/dB(A)	Duration of Measurement/ mm:ss	L_{Aeq} /dB(A)	Duration of Measurement/ mm:ss	Comms SNR (dB)	Maneouvre
Navigator	78.0	01:47:12	71.6	00:56	85.6	01:01	6.4	Cruise
Flight Engineer	81.8	01:36:45	76.0	00:57	82.3	00:30	5.8	Cruise
Right-hand Pilot	83.1	00:30:00	75.6	00:30	83.4	01:01	7.5	Cruise

Table 7 - Measured Aircrew Noise Data Acquired During Manoeuvres and Circuits Training Sortie on 29 Jun 05

	At Ear Data				Ambient Noise Data			
Position	L_{Aeq} With Comms/dB(A)	Duration of Measurement/ hh:mm:ss	L_{Aeq} Without Comms/dB(A)	Duration of Measurement/ mm:ss	L_{Aeq} /dB(A)	Duration of Measurement/ mm:ss	Comms SNR (dB)	Maneouvre
Flight Engineer	76.9	01:23:59	70.0	00:48	82.3	00:30	7.0	Circuits
Left-hand Pilot	82.9	02:00:07	79.8	01:46	81.1	01:01	3.1	Circuits
Loadmaster	85.4	01:59:48	81.9	02:10	93.2	00:31	3.5	Circuits
Navigator	84.3	01:53:50	72.5	01:01	85.6	01:01	11.8	Circuits

ANNEX C TO
OEM/130/05
DATED DEC 05

MEASURED OCTAVE BAND INSERTION LOSS FIGURES

Table 1 - Measured Octave Band Insertion Loss for the Racal Atlantic Headset

Frequency Band/Hz	63	125	250	500	1000	2000	4000	8000
Mean/dB(A)	-0.2	-0.2	7.0	15.3	12.1	15.8	22.7	19.6
S.D./dB	8.5	7.7	7.5	6.5	8.5	8.1	7.0	6.5

ANNEX D TO
OEM/130/05
DATED DEC 05

AMBIENT AND CALCULATED PROTECTED L_{Aeq} VALUES FOR CARGO AREA PASSENGERS

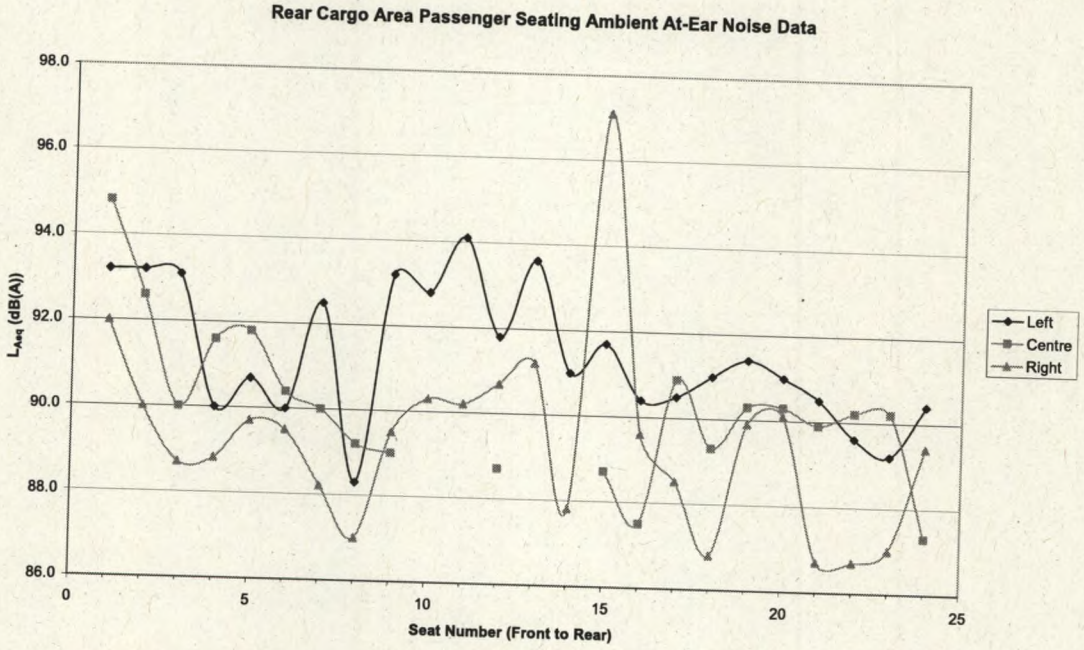


Figure 1: Measured Ambient At-Ear L_{Aeq} Value for Cargo Area Passengers.

Table 1 - Ambient and Calculated Protected L_{Aeq} Values for Left-hand Side Passenger Seating

Seat Number	Measured $L_{Aeq/dB(A)}$	Protected $L_{Aeq/db(A)}$
1	93.2	71.0
2	93.2	65.3
3	93.1	71.2
4	90.0	65.7
5	90.7	65.7
6	90.0	66.3
7	92.5	71.1
8	88.3	66.5
9	93.2	71.8
10	92.8	68.5
11	94.1	72.6
12	91.8	68.4
13	93.6	72.6
14	91.0	67.5
15	91.7	68.3
16	90.4	67.2
17	90.5	65.5
18	91.0	66.0
19	91.4	66.3
20	91.0	66.8
21	89.6	66.2
22	89.2	66.0
23	90.4	65.8
24	87.3	66.5

Table 2 - Ambient and Calculated Protected L_{Aeq} Values for Centre Passenger Seating

Seat Number	Measured $L_{Aeq/dB(A)}$	Protected $L_{Aeq/db(A)}$
1	94.8	72.7
2	92.6	68.5
3	90.0	67.1
4	91.6	69.5
5	91.8	70.2
6	90.4	68.8
7	90.0	68.6
8	89.2	67.4
9	89.0	67.5
10	Not measured	N/A
11	Not measured	N/A
12	88.7	67.0
13	Not measured	N/A
14	Not measured	N/A
15	88.7	66.6
16	87.5	65.2
17	90.9	69.9
18	89.3	67.8
19	90.3	68.0
20	90.3	66.1
21	89.9	65.2
22	90.2	64.6
23	90.2	65.1
24	87.3	65.8

Table 3 - Ambient and Calculated Protected L_{Aeq} Values for Right-hand Side Passenger Seating

Seat Number	Measured $L_{Aeq/dB(A)}$	Protected $L_{Aeq/db(A)}$
1	92.0	71.0
2	90.0	67.2
3	89.6	65.5
4	88.8	65.4
5	89.7	68.6
6	89.5	65.0
7	87.4	64.6
8	87.0	64.9
9	89.5	66.7
10	90.3	76.5
11	90.2	65.4
12	90.7	65.8
13	91.2	66.0
14	87.8	66.0
15	97.8	73.3
16	89.6	65.7
17	88.5	67.6
18	86.8	65.8
19	89.9	65.5
20	90.1	65.1
21	86.7	65.5
22	86.7	65.5
23	87.0	65.3
24	89.4	68.1