



USAARL-TECH-TR--2024-22

**UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY**

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## **Army Aviator Hearing Trends: 2016-2023**

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*Form Approved  
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<b>1. REPORT DATE (DD-MM-YYYY)</b> 12-04-2024		<b>2. REPORT TYPE</b> Technical Report		<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b> Army Aviator Hearing Trends: 2016-2023				<b>5a. CONTRACT NUMBER</b>	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b>	
<b>6. AUTHOR(S)</b> Noetzel, J. <sup>1</sup> , Henry, P. <sup>1,2</sup> , Stefanson, JR <sup>1</sup> , & Jones, H. G. <sup>1</sup>				<b>5d. PROJECT NUMBER</b> 2022-015	
				<b>5e. TASK NUMBER</b>	
				<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> U.S. Army Aeromedical Research Laboratory P.O. Box 620577 Fort Novosel, AL 36362				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> USAARL-TECH-TR--2024-22	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> U.S. Army Medical Research and Development Command Military Operational Medicine Research Program 504 Scott Street Fort Detrick, MD 21702-5012				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> USAMRDC MOMRP	
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b> DISTRIBUTION STATEMENT A. Approved for public release: distribution is unlimited.					
<b>13. SUPPLEMENTARY NOTES</b> <sup>1</sup> U.S. Army Aeromedical Research Laboratory, <sup>2</sup> Goldbelt Frontier, LLC					
<b>14. ABSTRACT</b> Two Army databases were used to determine the current prevalence and severity of hearing loss among Army aviators and to determine the degree to which waivers are issued for hearing function. Data pulled from the Defense Occupational Environmental Health Readiness System (DOEHRS) database across years 2016 and 2020 along with data pulled from the Aeromedical Electronic Resource Office (AERO) across 1 January 2020 to 11 December 2022 were compared to give an overall picture of the rates of hearing loss. The results of the DOEHRS analysis demonstrated about 6% of the aviator population presented with hearing loss outside the standard identified in the Aeromedical Policy Letter. The results of the AERO analysis demonstrated that approximately 100 waivers are submitted each year, indicating that 1% of Army aviators have a new hearing loss diagnosis. Aviators who fall outside of the standard were nearly always provided a waiver if they were already trained (upon entry) or, if the waiver was needed for continued service. Further research is needed to determine the degree to which aviator performance is impacted by hearing loss that exists beyond the standard.					
<b>15. SUBJECT TERMS</b> hearing loss, aviation, fitness for duty					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b> SAR	<b>18. NUMBER OF PAGES</b> 20	<b>19a. NAME OF RESPONSIBLE PERSON</b> Loraine St. Onge, PhD
<b>a. REPORT</b> UNCLAS	<b>b. ABSTRACT</b> UNCLAS	<b>c. THIS PAGE</b> UNCLAS			<b>19b. TELEPHONE NUMBER (Include area code)</b> 334-255-6906

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## Summary

Two Army databases were used to determine the current prevalence and severity of hearing loss among Army aviators and to determine the degree to which waivers are issued for hearing function. Data pulled from the Defense Occupational Environmental Health Readiness System (DOEHRS) across years 2016 through 2020, along with data pulled from the Aeromedical Electronic Resource Office (AERO) from 1 January 2020 to 11 December 2022 were compared to give an overall picture of the rates of hearing loss. The results of the DOEHRS analysis demonstrated a prevalence of hearing loss in the aviator population at about 6% (ranging from 697 to 848 aviators per year). The results of the AERO data showed that approximately 100 waivers are submitted per year, indicating that 1% of aviators have a new hearing loss diagnosis, and fail to meet the Aeromedical Policy Letter (APL) standard. Aviators who fall outside of the standard are nearly always provided a waiver if they are already trained (upon entry) or if a waiver is needed for continued service. The latest regulation, Department of the Army Pamphlet (DA PAM) 40-502, proposes that 10% of current aviators' functional auditory performance should undergo reevaluation. It also introduces the Military Operational Hearing Test (MOHT) as a potential solution for providing auditory performance data for flight surgeons when making decisions about waivers. Consideration should be made to update the APL to include the MOHT. Further research is needed to determine the degree to which aviator performance is impacted by hearing loss that exists beyond the standard.

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## **Acknowledgements**

Special thanks to LTC Kara Cave for her visionary initiative and beginning the deep dive into Army aviation audiometric trends. Her dedication as a scientist at the U.S. Army Aeromedical Research Laboratory, spearheading the institutional review board process and data collection, laid the foundation for this endeavor, even as it continued beyond her direct involvement.

This research was supported in part by Dr. James (Jim) McGhee who had an appointment at the U.S. Army Aeromedical Activity administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the U.S. Department of Energy and the U.S. Army Medical Research and Development Command. The research team would like to personally thank Dr. McGhee for all of his help and enthusiasm in pulling the AERO data, as well as his thoughtful analysis and insight.

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## **Introduction**

The objectives of this technical report are to review the current Department of Army and Army Aeromedical Policy Letter (APL) hearing loss standards, describe the prevalence of hearing loss within the Army aviation community, and outline how current hearing loss assessments are considered for exception to policy waivers. Aviators are annually assessed regarding their fitness-for-duty and audiometric data is collected to ensure they continue to meet APL standards. However, there are exceptions to policy or waivers that are issued to aviators who exceed the standard. Investigation into those aviators would be valuable for revalidating the current APL hearing standard and would allow targeted intervention for those individuals with hearing loss.

### **Current Hearing Fitness-For-Duty Standards**

Fitness-for-duty standards for hearing delineated in Department of the Army Pamphlet (DA PAM) 40-502, Army Regulation (AR) 40-501, and Aeromedical Policy Letter (APL) are based solely upon pure tone audiometric thresholds. The Army has recently updated its medical readiness standards in terms of hearing acuity and auditory fitness-for-duty (AR 40-501: Department of the Army, 2019a; DA PAM 40-502 Medical Readiness Procedures: Department of the Army, 2019b). Hearing loss assessments and profiling conditions were changed dramatically under the revision.

Consideration for performance on the new assessments, (i.e., the Military Operational Hearing Test [MOHT]) and profiling conditions should be investigated for the aeromedical community to update the APL or inclusion criteria for any exception to policy or waiver. The APL hearing standard, by way of audiometric thresholds or waiver criteria, has not been updated for decades. Currently, for aviators who do not meet the pure tone threshold standards, waivers are granted based on whether they meet the criterion value of greater than or equal to 84% binaural word recognition in quiet. However, no research exists that directly supports the predictive value of pure tone thresholds or word recognition in quiet on aviator-related performance. A thorough explanation of current Army and APL hearing standards follows.

#### **Hearing assessment.**

The current gold standard for measuring hearing sensitivity in individuals is the behavioral audiogram. The measured response is the absolute hearing detection threshold and is recorded in decibels hearing level (dB HL) for each frequency tested (Hertz [Hz]). See Figure 1 for examples of a graphic and a serial audiogram. Humans have a hearing sensitivity range of 20 to 20,000 Hz; however, the auditory system is especially sensitive to frequencies between 1500 to 6000 Hz. This frequency range is the most important for speech communication. Typical audiograms record thresholds for both the left and right ear individually for octave frequencies 250 to 8000 Hz plus interoctaves 3000 and 6000 Hz. Behavioral audiograms are completed annually on all Service Members and recorded and monitored using the Department of Defense (DoD) system called Defense Occupational Environmental Health Readiness System-Hearing Conservation (DOEHRS-HC). The annual hearing test is conducted using an automated system in a group setting.

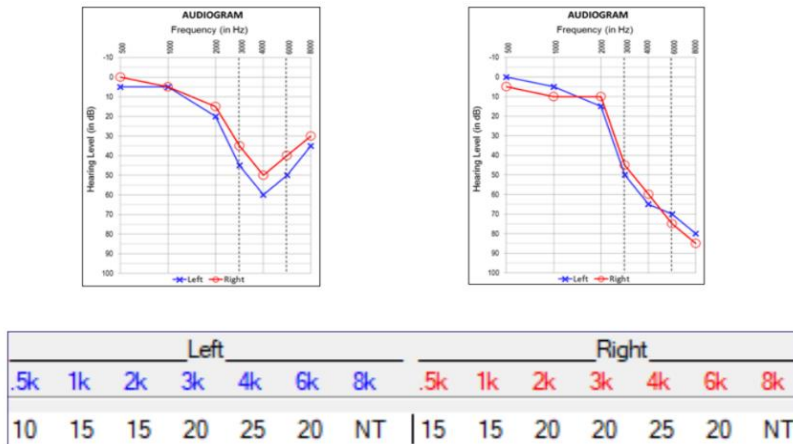


Figure 1. Two different graphic pure tone audiograms (top) and a serial audiogram (bottom) example from DOEHRS.

The DOEHRS-HC is the DoD database used for entering, assessing, comparing, and reporting hearing conservation and hearing readiness data, to include audiologic monitoring of all Service Members. Annual comparison of audiograms through DOEHRS-HC can reveal changes in an individual’s hearing sensitivity when compared to their baseline audiogram. This allows for early detection and prevention of hearing loss, as well as verification of auditory fitness-for-duty. The DOEHRS-HC data repository is also the retrieval and reporting platform used to aggregate audiometric data for reporting readiness and ongoing surveillance. The DOEHRS-HC system is a DoD enterprise-wide system that allows Service Members to relocate or deploy to various duty stations and remain trackable.

During the annual hearing readiness evaluation, the Service Member’s current results are compared to their baseline audiogram. A referral is generated if certain conditions are met, such as hearing loss, changes in hearing status, or asymmetric hearing loss. In these instances, Service Members may require comprehensive audiological evaluations, which may consist of immittance measures assessing the middle ear systems (tympanometry and acoustic reflex assessments), otoacoustic emissions measuring outer hair cell function in the cochlea, and speech testing conducted in either quiet or noise. These tests are not automated; rather, they are conducted by a licensed clinical audiologist. Military medical standards help guide the disposition of the Service Member.

**Military medical standards for hearing.**

Medical accession and entrance standards are outlined by the DoD as well as each individual Service (Army, Navy, and Air Force). The DoD Instruction (DoDI) 6130.30-V1 *Medical Standards for Military Service: Appointment, Enlistment, or Induction* (2022) outlines by threshold (HL) and frequency (Hz) what would disqualify an individual for initial entrance into the DoD. These criteria are shown in Figure 2. Failure to meet any single condition is grounds for disqualification and renders an individual unable to enter military service. In addition to the DoDI, each individual service component has their own additional set of requirements.

<p>Current hearing threshold level in either ear that exceeds:</p> <ul style="list-style-type: none"> <li>• 25 dB averaged at 500, 1000, and 2000 Hz</li> <li>• 30 dB at 500, 1000, or 2000 cycles per second</li> <li>• 35 dB at 3000 Hz</li> <li>• 45 dB at 4000 Hz</li> <li>• No standard for 6000 Hz</li> </ul>
<p>Unexplained asymmetric hearing loss as defined by a difference of 30 or more dB between the left and right ears at any one or more frequencies between 500, 1000, 2000 Hz</p>

Figure 2. Service Member hearing thresholds as indicated by DoDI 6130.03-V1 (Department of Defense, 2022).

The initial entrance standards for the Army are governed by AR 40-501 *Medical Standards of Fitness*, while continued service and individual medical readiness are governed by AR 40-502 *Medical Readiness* and DA PAM 40-502 *Medical Readiness Procedures*. AR 40-502 also outlines various medical requirements for duties or jobs beyond initial entry to include Special Forces, Survival, Evasion, Resistance, and Escape (SERE) training, divers, Ranger Regiment, and aviation. Additionally, Army aviation has APLs that guide medical entrance and retention standards for Army aviators. The APL hearing criteria are stricter than regular Army medical standards outlined in any regulation. When an individual does not meet a requirement, an exception to policy or waiver is required for them to enter or continue service.

Medical disqualifications and medical waivers among a cohort of military applicants from 2016 to 2020 were examined in the epidemiological Accession Medical Standards Analysis & Research Activity – 2022 Annual Report (Weber et al., 2022), Military Entrance Processing Station (MEPS). This report describes the auditory status of new Service Members. Over the four-year span studied, the Army disqualified 2777 applicants (3.1%) based on failure to meet hearing criteria. Of those disqualified, only 12.2% ( $n = 339$ ) were accepted for service. Measuring over four years, the trend for disqualification rose, meaning that in 2016, only 0.8% of individuals were disqualified for hearing and in 2020, 6.3% of individuals were disqualified. This suggests that more applicants are presenting with hearing loss and are being denied entry when they don't meet the DoDI standard. Waiver approval rates were examined across disqualification criteria. Over the four years studied, the lowest waiver approval rates were for hearing (13%), which means that waivers are rarely granted to those exhibiting hearing loss at entry. As opposed to entrance into the Army, continued service is governed by DA PAM 40-502, *Medical Readiness Procedures* (Department of the Army, 2019b). All Army Service Members are enrolled into a hearing conservation program because of the innate noise exposure that accompanies military service. One requirement of the hearing conservation program is that all Service Members receive a yearly audiologic evaluation to assess for hearing loss or shifts in

their hearing status. All Service Members are assigned a hearing profile as part of their annual exam, which is an indication of their current hearing status. Hearing profiles are designated serially from H1 to H4. H1 suggests the best hearing, or that the individual is fully qualified for service based on their hearing ability. There is an expectation that the H1 hearing status will have no impact on the Service Member’s performance. As the number designator increases, so does the anticipated degree of impact on performance (e.g., H2, H3, and H4). Higher number designators are assigned after a diagnostic audiological assessment.

In 2019, AR 40-502 was updated, replacing AR 40-501 (*Standards of Medical Fitness*) (Department of the Army, 2019a), and clarified the retention standard for hearing assessment with a diagnostic audiological evaluation and for the first time, functional performance on the MOHT. Used in conjunction with AR 40-502, the updated DA PAM 40-502 outlines hearing profiles based on audiometric thresholds and performance on the MOHT. Values for H1 and H2 profiles are outlined in Table 1.

*Table 1. DA PAM 40-502 Audiometric Thresholds (dB HL) for Hearing Profiles H1 and H2*

<b>Profile</b>		<b>500 Hz</b>	<b>1000 Hz</b>	<b>2000 Hz</b>	<b>3000 Hz</b>	<b>4000 Hz</b>	<b>6000 Hz</b>
<b>H1</b>	<b>Better ear</b>	≤ 25	≤ 25	≤ 25	≤ 25	≤ 25	≤ 60
	<b>Worse ear</b>	≤ 30	≤ 30	≤ 30	≤ 35	≤ 45	-
<b>H2</b>	<b>Better ear</b>	≤ 25	≤ 30	≤ 25	≤ 40	≤ 60	≤ 70
	<b>Worse ear</b>	≤ 40	≤ 40	≤ 60	-	-	-

This update of hearing profiles for Army Service Members was implemented after years of research conducted at Walter Reed National Military Medical Center (Brungart et al., 2023). The previous profiling system was based primarily off of Service Members’ pure tone thresholds. The MOHT was designed to evaluate the functional auditory performance of individuals with elevated auditory threshold levels. Operational effectiveness is correlated with auditory thresholds; however, individual performance on mission critical auditory tasks can vary significantly. Therefore, if a Service Member’s audiometric thresholds exceed the H2 profile pure tone threshold criteria, the MOHT is administered, and functional performance dictates profile designation. The MOHT is comprised of three components: 1) a diagnostic audiological evaluation including pure tone auditory thresholds and monaural word recognition in quiet scores for each ear, 2) an assessment of speech-in-noise performance by administering the clinical adapted 80-word Modified Rhyme Test (MRT<sub>80</sub>), and 3) an evaluation of spatial awareness obtained by administering the Spatial Digit Test (SDT) for individuals with significant hearing deficits in at least one ear.

**Profile determinations and MOHT administration.**

All Service Members are required to complete an annual hearing readiness audiogram recorded in the DOEHRS system as part of their enrollment into the Army hearing program and ongoing monitoring. If a Service Member’s annual audiogram presents with thresholds that exceed the DA PAM 40-502 standards, they are then referred to an audiologist for a comprehensive audiological assessment. If the audiometric thresholds exceed H1 values, but not H3 values, they are assigned to hearing profile H2, and no further assessment is required. If a Service Member’s audiometric thresholds exceed H2 values, they are not guaranteed an H3

profile because the MOHT is administered to make the profile determination. Table 2 outlines the MOHT scoring criteria and respective profile designations.

Table 2. MOHT Profile Determinations

	<b>H2 Profile</b>	<b>H3 Profile</b>	<b>H4 Profile</b>
<b>Monaural Word Recognition Score (WRS)</b>	≥ 78% in both ears	≥ 78% in better ear	< 78% in better ear
<b>Modified Rhyme Test (MRT<sub>80</sub>)</b>	Better ear ≤ 20 dB at 2000 Hz; MRT ≥ 55/80 or 104/160 Better ear > 20 dB at 2000 Hz; MRT ≥ 59/80 or 112/160	≥ 80/160	< 80/160
<b>Spatial Digit Test (SDT) or Low Frequency Thresholds</b>	SDT ≥ 8/10 (or) Worse ear ≤ 40 dB at 500 Hz; and ≤ 40 dB at 1000 Hz; and ≤ 60 dB at 2000 Hz	Not applicable (N/A)	N/A

Monaural word recognition in quiet is the first criterion to consider, with 78% correct designated as the cutoff. If the monaural word recognition score is equal to or better than 78% in both ears, the MRT<sub>80</sub> is administered. The criterion for a passing score is based on the Service Member’s pure tone threshold in the better ear at 2000 Hz. Greater hearing loss requires the Service Member to perform better on the MRT<sub>80</sub> in order to retain an H2 profile designation. If the Service Member meets the passing score after the administration of the MRT<sub>80</sub>, testing is complete; however, if the Service Member does not meet the passing score, a second list is administered, and the score is calculated out of a 160-word set (two administrations of the MRT<sub>80</sub>) as opposed to a single 80-word set. The MOHT is standardized across all Army military treatment facilities (MTFs) via a tablet-based system with the MRT<sub>80</sub> and SDT preloaded. The tablet is interfaced with a clinical audiometer for calibrated administration. The Service Member completes the MRT<sub>80</sub> and the SDT under headphones, if applicable.

The spatial awareness criteria are designed to ensure that Service Members who have audiometric thresholds that are at H3 levels are not reassigned to H2 unless they have some ability to identify and localize sounds. For individuals who score a monaural word recognition of more than or equal to 78%, but present with significant low to mid frequency hearing loss in the worse ear (i.e., thresholds higher than 40 dB HL at 5000 Hz, higher than 40 dB HL at 1000 Hz, or higher than 60 dB HL at 2000 Hz), further assessment is required. The Service Member must correctly identify the digit in the target ear for 8 out of 10 trials to obtain a passing score. Good hearing sensitivity in the low frequencies precludes the need for SDT testing. If the Service Member’s performance meets all the criteria under the following sections: 1) monaural word recognition score, 2) MRT<sub>80</sub>, 3) SDT or low frequency thresholds, they can be reassigned from H3 to a H2.

### Army aeromedical standards for hearing.

Aeromedical concerns for hearing loss include difficulty with in-flight communications, radio transmissions, and rapid and accurate assessment of warning tones in the cockpit. All these auditory tasks can impact flight safety and mission success. Inclusion into Army aviation requires even stricter adherence to auditory thresholds and referral criteria. Aviators are required to complete annual audiological evaluations adhering to the DoD hearing readiness referral criteria (i.e., significant threshold shifts averaging 10 dB, etc.). Additionally, aviators must adhere to the APL referral criteria, such as a 20 dB shift in either ear at a single frequency (1000 through 4000 Hz), requiring a full audiological evaluation. The APL outlines serial Class (C) categories 1 through 4 (C1-C4). Generally speaking, all aviator applicants are identified as Class 1, with exceptions being granted to pilots transferring from another Service or pilots rated internationally. Class 2 includes all rated aviators or front seaters. Class 3 and 4 includes trained aviation personnel with a requirement for flight status and includes flight surgeons, aircrew, air traffic controllers, and unmanned aerial system (UAS) operators. Table 3 outlines the audiological thresholds for C1 and C2/3/4 categories.

Table 3. APL Hearing Standards

	<b>500 Hz</b>	<b>1000 Hz</b>	<b>2000 Hz</b>	<b>3000 Hz</b>	<b>4000 Hz</b>	<b>6000 Hz</b>
<b>Class 1</b>	≤ 25	≤ 25	≤ 25	≤ 35	≤ 45	≤ 45
<b>Class 2/3/4</b>	≤ 25	≤ 25	≤ 25	≤ 35	≤ 55	≤ 65

If the Class category is met with audiological thresholds alone, no further assessment is required. If an aviator does not meet the APL standard, an exception to policy (ETP) or waiver is considered. An ETP is for applicants wishing to enter aviation and a waiver is for individuals already in service and wishing to continue. According to the APL, hearing loss designated with an H2 profile may or may not be a disqualifying condition. Most Service Members with an H2 profile can apply for a waiver if their hearing status does not impact flight performance, which is then determined by a flight surgeon. Waivers are not recommended for Service Members with an H3 hearing profile. Waivers are considered on a case-by-case basis.

The current audiological workup required for waiver consideration includes pure tone air and bone conduction testing, tympanometry, acoustic reflex testing, speech reception threshold (SRT) testing, and word recognition scores (WRS) in quiet in both monaural and binaural conditions. There is a requirement to score greater than or equal to 84% on binaural WRS. If an aviator scores lower than 84%, the APL notes a requirement for an in-cockpit/flight evaluation. This evaluation is determined by the flight surgeon and is not standardized. The in-flight/cockpit evaluation is an attempt to ensure that hearing loss does not have a functional impact on the aviator's operational performance. However, in-flight/cockpit evaluations are fiscally and time intensive compared to clinical evaluations and are rarely performed.



## Aviator Audiometry Trends From 2016-2023

DOEHRS and Aeromedical Electronic Resource Office (AERO) data were examined to understand the current status of hearing loss in the aviation community. The designated areas of concentration (AOC) of Service Members in aviation, as shown in Table 4, were used to determine the scope of hearing loss in Army aviators over the span of five years (2016-2020). Only audiometric thresholds were included in the data pull; no demographic data such as gender or age were provided. Data were analyzed according to auditory threshold requirements in the updated DA PAM 40-502, legacy AR 40-501, and the APL. AERO data from 1 January 2020 through 11 December 2022 were used to determine the most current numbers of pilots with International Classification of Diseases (ICD)-10 hearing loss codes and new or continuing waiver dispositions, as well as in-flight evaluations. The discrepancy in the calendar years pulled from the DOEHRs and AERO databases is a result of study delays related to COVID-19. Note that these data are meant to gain an understanding of the scope of the problem and are not meant to be directly compared.

*Table 4.* Aviation AOC Designators Retrieved from DOEHRs for Analysis

Alpha-numeric AOC designator	Occupation description
152C	OH-6 pilot
152D	OH-58D pilot
152E	RAH-66 Comanche pilot
152H	AH-64D Attack pilot
153A	Rotary-wing aviator
153D	UH 60 pilot
153E	MH-60 pilot
153M	UH-60M pilot
154E	MH-47 pilot
154F	CH-47F pilot
15A	Aviation officer
15B	Aircraft powerplant repairer
67J	Medical evacuation (MEDEVAC) pilot

*Table 5.* DOEHRs Data Demonstrating the Percentage of Aviators Who Meet or Exceed the APL C2 Standard

	CY16	CY17	CY18	CY19	CY20
<b>Meet C2 standard</b>	94.1%	93.7%	93.4%	93.8%	93.7%
<b>Exceed C2 standard</b>	5.9%	6.3%	6.6%	6.2%	6.3%

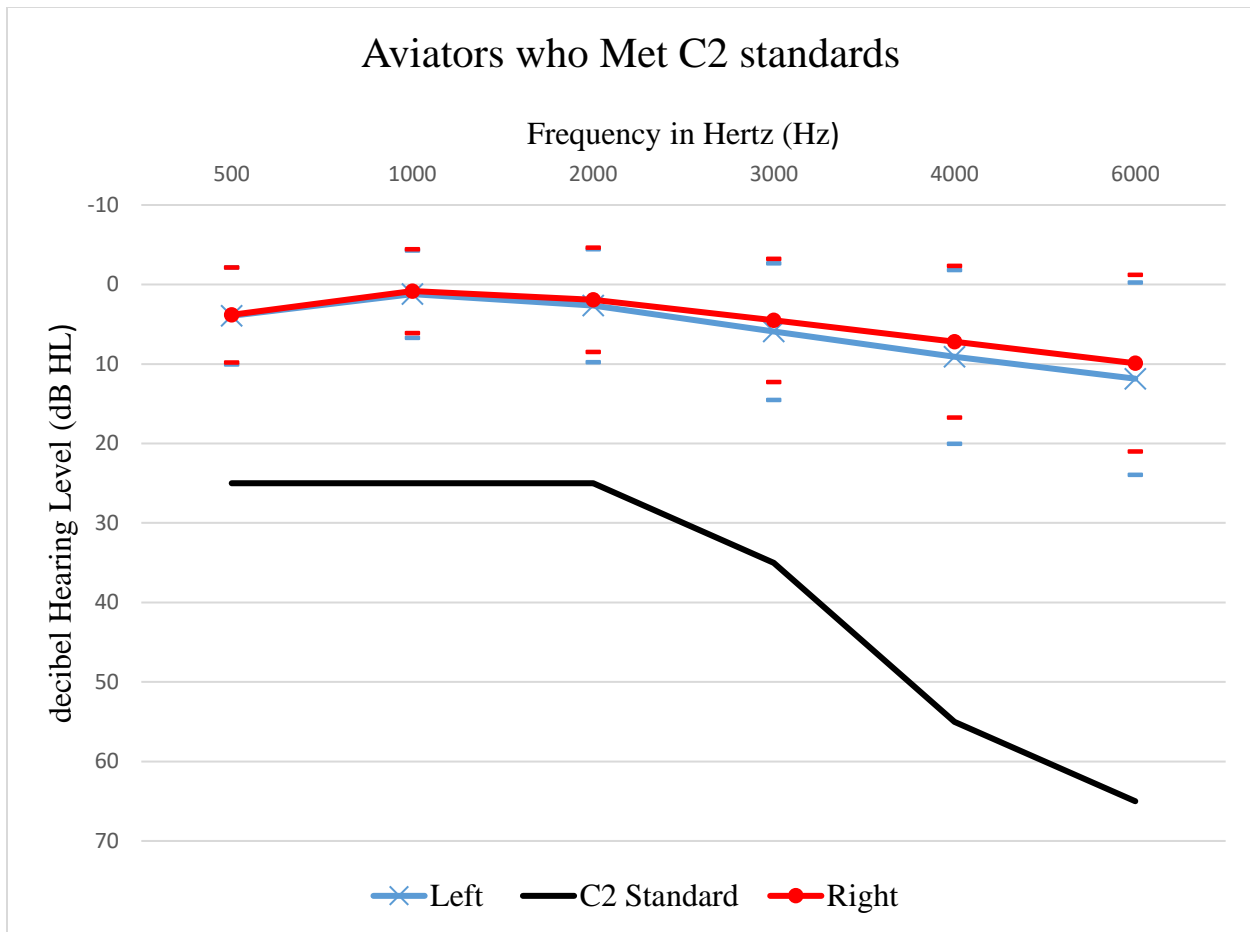


Figure 3. Average audiometric thresholds with standard deviations of aviators who meet the C2 APL standard pulled from DOEHRS for CY2020.

Overall, aviators met the C2 standard outlined in the APL as shown in Table 5. On average, 94% passed the C2 standard during the period of calendar year (CY) 16-20; conversely, about 6% of pilots failed to meet the C2 APL standard in this same period. This would suggest that hearing levels are generally near normal for most aviators and hearing loss does not typically exceed a moderate degree. The next step was to examine what the audiometric configurations looked like for each condition. This was completed only for the year 2020, which is the most recent year in this dataset.

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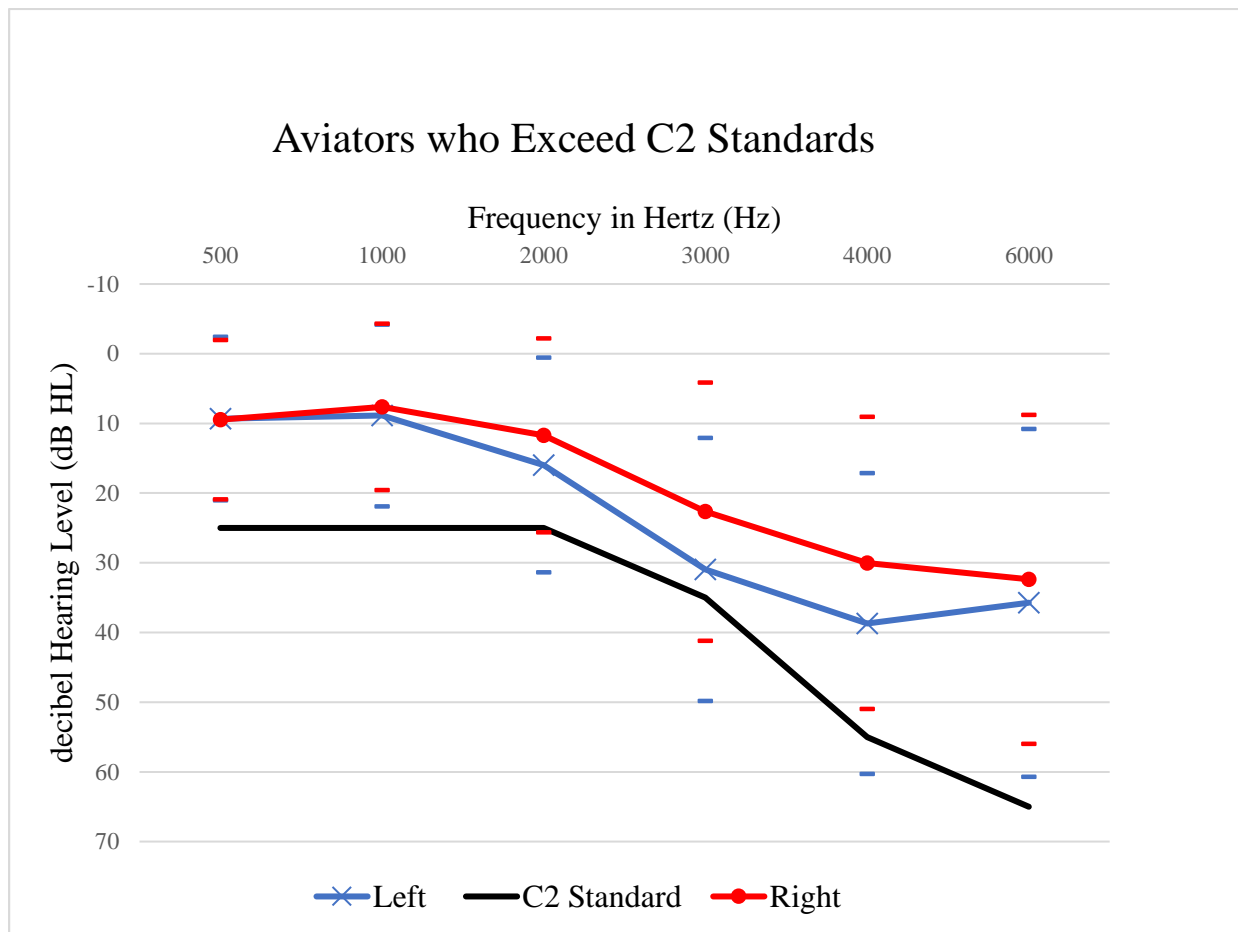


Figure 4. Average audiometric thresholds with standard deviations for aviators who exceed the C2 APL standard pulled from DOEHRs for CY2020.

Average audiometric thresholds with standard deviations for aviators who met the APL C2 standard are presented in Figure 3. Average audiometric thresholds with standard deviations for aviators who exceeded the C2 standard are presented in Figure 4. On average, for those that met the C2 standard, there was no hearing loss present, as all thresholds are below 25 dB HL and well below the C2 standard (depicted as solid black line). As expected, variability increases with frequency, particularly in the higher frequencies where hearing loss typically begins. The pattern of lower variability at the lower frequencies and heightened variability with higher frequencies persists for aviators surpassing the C2 standard, albeit to a much greater extent. Notably, threshold variability is less in aviators who met the C2 standard (5 to 12 dB) compared to those who exceeded it (11 to 24 dB). For those who exceeded the C2 standard, the left ear audiometric thresholds were worse than the right ear thresholds, primarily in the high frequencies. Whereas no hearing loss was typically found in the C2 group, it was more likely for high frequency hearing loss to be present at frequencies 3000, 4000, and 6000 Hz in the left ear and 4000 and 6000 Hz in the right ear for those who exceeded the C2 standard. It is not unusual for Service Members to have decreased hearing levels in the left ear compared to the right ear. This is a condition often referred to as ‘shooter’s ear,’ where there is elevated hearing loss in the ear opposite the shooting hand due to higher noise exposure in that ear during rifle shooting. And whereas most people in the population are right-handed, the incidence of left sided hearing loss is more prevalent (Gordon et al., 2017). Frequencies where aviators tend to exceed the standard were 2000, 3000, and 4000 Hz. The hearing loss present in the higher frequencies particularly at

4000-6000 Hz is often commonly known as a noise notch, a configuration consistent with noise-induced hearing loss (NIHL).

*Table 6. Whole Counts of Aviators that Exceeded C2 Standards*

<b>Calendar year</b>	<b>Total counts</b>	<b>%</b>
<b>CY16</b>	809	5.9%
<b>CY17</b>	848	6.3%
<b>CY18</b>	792	6.6%
<b>CY19</b>	803	6.2%
<b>CY20</b>	697	6.3%
<b>Five-year average</b>	790	6.3%

Table 6 reflects the whole number counts with the corresponding percentage. These numbers are not cumulative in nature and represent a snapshot of each year. In any given year, Service Members retire, depart service, change flight status, or change their AOC. The percentage of aviators who exceed the C2 standard each year seems stable at about 6%, with the whole count ranging from 697 to 848 aviators, averaging 790 per year. The aviation dataset from DOEHRS varied from 13,000 to 15,000 audiograms per calendar year.

### **Hearing Loss Trends by Aviation AOC**

It is important to assess the rates of hearing loss within the various aviation AOCs or airframes. Based on the dataset, Class 2 APL fail rates are less than 10% (ranging from 2.7 to 9.2%) across all the aviation AOCs as shown in Table 7. Overall, fewer than 900 aviators exceeded the APL C2 standard during CY 16-20. The MH-47 pilot (154E) had two consecutive years of a 12% fail rate, which was the highest percentage for any individual calendar year. The highest five-year average fail rate was the OH-58D pilot (152D), averaging 9.2%, but this is a smaller AOC and included only 80 pilots over five years, averaging about 16 individuals per year. This airframe was retired in 2016 and is likely the reasoning why the AOC is small and conversely the percentage high. There are no new pilots being added to this group. The highest whole count was aircraft powerplant repairer (15B) totaling 1139 Service Members, averaging 227 per year followed by UH-60 pilots (153D), averaging 130 Service Members per year. The numbers presented are not cumulative but are indicative of the prevalence of hearing loss for that calendar year for that AOC. Viewing from the opposite lens, aviation officers (15A) had the highest pass rate, averaging 97.3% while OH-58D pilots (152D) had the lowest pass rate, averaging 90.8%.

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Table 7. Five Year Average Class 2 Fail Rate by AOC

<b>AOC</b>	<b>Five-year average</b>	<b>Five-year total count</b>	<b>Average count per year</b>
152D	9.2%	80	16
153E	8.4%	61	12
154E	7.8%	40	8
153A	7.1%	466	93
154F	7.1%	206	41
152H	7.0%	343	69
153D	6.2%	653	131
15B	5.9%	1139	228
153M	5.6%	378	76
152E	5.4%	96	19
152C	4.9%	15	3
67J	3.8%	111	22
15A	2.7%	361	72

### Hearing Loss Asymmetry Data from DOEHRS

There is currently no standard for asymmetry in hearing acuity in the APL. The DoDI's definition of asymmetric hearing loss is a difference of 30 dB or more between the left and right ears at any one or more frequencies of 500, 1000, and 2000 Hz. This definition was applied to the DOEHRS data to determine the rates of asymmetry. There appears to be a small number, less than 1% of aviators, who are affected by this amount of asymmetry. Table 8 provides the breakdown by calendar year. The DOEHRS system flags asymmetric hearing loss when there is a right-left ear difference of 25 dB or more at two consecutive frequencies. This is not an exclusionary standard, but one that flags an individual for a follow-up comprehensive audiological evaluation. Less than 4% of aviators meet this criterion for asymmetric hearing loss. Table 9 provides the breakdown in DOEHRS by calendar year. Simply put, asymmetry is not a frequent condition demonstrated in aviators, so it should not be considered a significant concern.

Table 8. Aviators with Asymmetric Hearing Loss as Defined by the DoDI

<b>Calendar year</b>	<b>Number of Service Members affected</b>	<b>Asymmetry %</b>
CY16	114	0.76%
CY17	119	0.79%
CY18	115	0.81%
CY19	113	0.82%
CY20	105	0.81%

Table 9. Aviators with Asymmetric Hearing Loss Flagged by DOEHRS

Calendar year	Number of Service Members affected	Asymmetry %
CY16	547	3.63%
CY17	535	3.52%
CY18	536	3.79%
CY19	510	3.69%
CY20	476	3.66%

To gain more clarity on the prevalence of hearing loss asymmetry, the 2020 DOEHRS data were broken down starting at a 10 dB difference, in bins increasing by 5 dB between the right and left ears. Results for 10, 15, 20, 25, and greater than 25 dB asymmetries were also calculated for each frequency for CY20 for Army aviation. Each frequency is independent, and an aviator may be included in multiple frequencies. The results are depicted in Table 10. Generally, as we increase the frequency, we increase the number of aviators who have asymmetry and see the degree of asymmetry increase. The largest count of aviators with asymmetry shows a 10 dB difference between ears.

Table 10. 2020 DOEHRS Data Depicting the Number of Service Members with Asymmetric Audiometric Thresholds at Each Frequency

Amount of asymmetry	500 Hz	1000 Hz	2000 Hz	4000 Hz	5000 Hz	6000 Hz
10 dB	1319	1107	1981	2356	2583	2763
15 dB	279	229	575	880	1122	1574
20 dB	63	69	171	338	522	791
25 dB	30	23	55	130	260	410
> 25 dB	65	67	126	393	736	1018

### Impact of DA PAM 40-502 Profiling System on Aviators

It is important to examine the impacts of hearing profile ratings under the new profiling standard in DA PAM 40-502 as profiles could have changed with the new standard, resulting in aviators being assigned to a higher profile that could limit their service. Recall that the APL applies only to aviators; however, the DA PAM 40-502 and AR 40-502 apply to all Service Members in the Army. This analysis examines the impact the new DA PAM 40-502 profiling system had on the aviation community. Given that the APL is a stricter criteria, if an aviator meets the C1 standard, they did not exceed the minimum H1 standard in either the old or new profiling system. If an aviator meets the C2 standard, they did not exceed the H2 standard in the new or old profiling system. If aviators meet the APL standard, they were not affected by the new profiling system in DA PAM 40-502.

Aviators who exceeded the C2 standard have either an H2 or greater than or equal to an H3 profile designation. More than 80% of the aviators maintained their current profile designation regardless of their H2 or greater than or equal to an H3 designation following the

implementation of the new standard. Using the updated regulation, aviators may have experienced a change in their profile designation based on pure tone thresholds alone. About 7% had their profile downgraded, meaning they were moved from a greater than or equal to H3 to an H2 profile which is seen as a good thing for the Service Member. The remaining 10% experienced an increase in their profile designation from an H2 to greater than or equal to an H3. This increase to exceed the H2 values now requires the aviator to complete the MOHT, to include the MRT<sub>80/160</sub> and the SDT, if applicable. The aviator’s performance on the MOHT is an opportunity to downgrade their profile to an H2. Whereas the pure tones would indicate that about 10% are greater than or equal to an H3, this number is likely smaller. DOEHRS data does not account for the MOHT, only pure tone thresholds, and that is one limitation of the system. Table 11 presents the change in profiles based solely on pure tone thresholds. Ultimately, the updated regulation resulted in profile changes for about 17% of aviators. The updated regulation, in every instance, moved more aviators to a higher profile (poorer hearing) category than to a lower profile (better hearing) status. This would suggest that about 10% of aviators require an additional assessment regarding their auditory fitness-for-duty.

*Table 11.* Whole Counts of Aviators Whose Profile Designation Changed as a Result of the Updated DA PAM 40-502 Compared to the AR 40-501

<b>Calendar year</b>	<b>Aviators who exceed the C2 standard</b>	<b>No change; maintained H2 profile</b>	<b>No change; <math>\geq</math> H3 profile</b>	<b>Downgrade in profile designation (<math>\geq</math> H3 to H2)</b>	<b>Upgrade in profile designation (H2 to <math>\geq</math> H3)</b>
CY20	697	516 (74%)	63 (9%)	45 (6%)	73 (10%)
CY19	803	590 (73%)	73 (9%)	60 (7%)	80 (10%)
CY18	792	576 (73%)	80 (10%)	54 (7%)	82 (10%)
CY17	848	611 (72%)	83 (10%)	60 (7%)	94 (11%)
CY16	809	586 (72%)	79 (10%)	64 (8%)	80 (10%)

### **Aeromedical Electronic Resource Office (AERO)**

The AERO system is the Army’s database for flight physicals and waiver submissions for aviators who do not meet the APL standards. The AERO database query returned the number of aircrew personnel who have a hearing loss-related ICD-10 code associated with their flight physical. AERO identified the number of hearing loss-related waivers requested, the number of new and continuing hearing waivers requested, and the disposition of hearing loss-related waivers for all physical APL Class categories (i.e., C1, C2-4). Although DOEHRS can identify the aviators who do not meet medical standards, AERO can provide detailed information regarding those who are granted waivers and remain active in Army aviation even though they do not meet the medical standard.

### **Exceptions to Policy or Waivers Collected From AERO Database**

The AERO database used the International Classification of Diseases, Clinical Modification (ICD-CM) to query diagnostic codes corresponding with hearing-related waivers. Table 12 identifies the ICD-10 codes queried. Between 1 January 2020 and 11 December 2022,

using these ICD-10 codes, 1078 encounters were recorded with at least one of the following diagnosis codes. Duplicate records were eliminated, leaving 746 unique patient records identified.

Table 12. ICD-10 Codes and Their Description; Number of Aviators with the Diagnosis Code

ICD-10 Code	N	Description
H83.3	1	Noise effects on inner ear
H90.0	0	Conductive hearing loss, bilateral
H90.11	13	Conductive hearing loss, unilateral with unrestricted hearing on the contralateral side; right ear
H90.12	10	Conductive hearing loss, unilateral with unrestricted hearing on the contralateral side; left ear
H90.2	9	Conductive hearing loss, unspecified
H90.3	293	Sensorineural hearing loss, bilateral
H90.4	14	Sensorineural hearing loss, unilateral with unrestricted hearing on the contralateral side
H90.41	207	Sensorineural hearing loss, unilateral, right ear, with unrestricted hearing on the contralateral side
H90.42	498	Sensorineural hearing loss, unilateral, left ear, with unrestricted hearing on the contralateral side
H90.5	20	Unspecified sensorineural hearing loss
H90.6	2	Mixed conductive and sensorineural hearing loss, bilateral
H90.71	1	Mixed conductive and sensorineural hearing loss, unilateral, right ear, with unrestricted hearing on the contralateral side
H90.72	3	Mixed conductive and sensorineural hearing loss, unilateral, left ear, with unrestricted hearing on the contralateral side
H90.8	2	Mixed conductive and sensorineural hearing loss, unspecified
H91.9	5	Unspecified hearing loss

The aeromedical summary (AS) is the official submission for new waivers. There is a different process for continuing hearing loss waivers already in place. The AS consists of the type of application (i.e., waiver or ETP), the medical condition, assessment, limitation, and discussion regarding the disposition (qualified or not qualified). The AS is submitted to the U.S. Army Aeromedical Activity (AAMA), the approval authority for waivers.

In the AERO dataset, 279 new waivers or ETPs between 2020 to 2022 were identified. Of the 279 patients, 166 were applicants (C1) and 163 were rated aviators (C2). The mean age for this group was 27 years ( $SD = 4.1$  years). In total, 116 C1 ETPs were submitted for hearing loss, only 5 (4%) were dispositioned as not qualified or their ETP not granted. Of the five that were not qualified, four had H3 profile designations and one was not qualified due to previous ear surgery because of a cholesteatoma, an ear-related medical condition.

There were 163 total AS submissions (i.e., new waiver submissions) for rated aviators (C2 physicals). The mean age for this group was 42 years ( $SD = 9.1$  years). The age difference of



C1 compared to C2 is logical considering C1 (applicants) are typically new to aviation and, therefore, younger, and C2 are already rated aviators. In this segment there was only one (< 1%) AS that resulted in a suspension from flying; however, this was not related to the diagnosed hearing loss; the cause for suspension was listed as severe tremor and degenerative cervical disease. One case was lost to follow-up for administrative reasons and four did not warrant waiver action (Information Only). There were 11 aviators listed with pre-existing waivers in the AS group. The presence of a waiver continuation request is atypical within the AS, as there is a separate process for waiver continuation; however, it can appear in the AS if a new waiver for an unrelated condition is requested or if there is a change in audiometric thresholds. It appears that it is slightly more difficult for an applicant (C1) to receive an ETP than it is for a rated aviator (C2).

All C2 rated aviators are required to receive an annual flight physical to remain on flight status. Aviators with an existing waiver must complete an additional Annual Waiver Requirement (AWR). There are two AWR codes related to hearing loss, 1) AWR72 is “hearing loss” and 2) AWRH5 is “must wear hearing aids.” If there is no change to the condition, the waiver is good indefinitely, unless a flight surgeon requests a new AS. Review of annual flight physicals revealed 348 rated aviators with pre-existing waivers dispositioned as waiver continued. Additionally, there were 15 applicants (C1) whose ETPs were continued (EC). There were 83 that were deemed simply qualified or listed as information only. In other words, the AAMA flight surgeons did not feel that the hearing loss diagnosis needed a waiver action.

There were 46 within the annual flight physical group listed as disqualified (DQ) or disqualified lacking complete information (DI). The AAMA flight surgeons seemed to use these dispositions interchangeably, so for the purpose of this examination, they will be considered as a single disposition category. Of this group of DQ/DI individuals, 24 were classified as C1 and 22 were classified as C2. A threshold shift of greater than 20 dB occurred in six, which requires revalidation of a pre-existing hearing loss waiver. Another 32 were returned to the originating flight surgeon requesting further evaluation in accordance with the hearing loss APL. In other words, the AAMA flight surgeon felt a waiver for hearing loss should be requested. In these cases, the physical was returned to the originating flight surgeon with an annotation that hearing standards were not met and to reference the hearing loss APL for complete work-up instructions.

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Table 13. Numbers of Aviators Who Applied For and/or Were Granted Waivers For Hearing Classifications from 2020-2022

	Class 1 (applicants)	Class 2 (rated aviators)
Aeromedical summaries (AS) <i>N</i> = 279	<i>N</i> = 116	<i>N</i> = 163
Dispositioned		
Granted	107	143
Not granted	5 (4%)	1 (< 1%)
Information only	-	4
ETP/waiver continued	-	11
Lost to follow up	-	1
Flight physicals	<i>N</i> = 39	<i>N</i> = 453
AWRH5 - must wear hearing aids	0	0
AWR72 - hearing loss	15	348
Waiver continued	15	348
Waiver suspended	0	0
Qualified or information only	0	83
Disqualified or disqualified lacking complete information	24	22
Subtotals	155	616
<b>Total: 771</b>		

The APL states that an aviator whose binaural word recognition score is less than 84% is required to undergo an in-cockpit/flight evaluation. This evaluation is determined by the flight surgeon and is not standardized. The AAMA oversees the waivers and tracks waiver submissions, approvals, and rejections. Based on the AS, AAMA currently has no monitoring or tracking system for in-flight evaluations. There can be comments written into the AS waiver submission regarding an in-flight evaluation. One of the five applicants determined not to be qualified for an ETP had the note, “See Memorandum for Record for in-flight speech intelligibility test,” but details about the administration and results were not directly entered into the AERO database. A second AS noted, “SM’s speech recognition testing is noted to have been greater than or equal to 84%, in cockpit/flight evaluation not required.”

This fragmented or non-standardized approach to waiver submission creates obstacles for obtaining audiometric data for comparison. The AERO-specific patient identification numbers were used to go back to the aeromedical summaries themselves to search for the pure tone thresholds, speech recognition threshold values, and word recognition scores. The data were found in one of several places, to include uploaded audiology reports from military and civilian audiology clinics, physical exam forms, and reports from associated physicals. The best reports were the DoD Hearing Center of Excellence forms often used by audiologists, but these were by no means the only reports used. Once the data elements were located, they were individually transcribed from the reports to a spreadsheet. This was a time intensive process that still resulted in incomplete and missing audiometric data. Therefore, AERO audiometric data were unable to be analyzed in any meaningful way.

The results of the AERO analysis show that, in total, nearly 96% of new ETPs were granted and 100% of existing ETPs were allowed to continue. For rated aviators, less than 1% of new waiver requests were denied and 100% of continued waivers were allowed to remain. There remains a small number of those individuals ( $N = 46$ ) who were dispositioned as disqualified or lacking complete information, which signals that they are in the process of waiver submission, but if current trends hold, they will likely be dispositioned as qualified.

The DOEHRS data suggests the percentage of aviators who exceed the C2 standard is much higher than the AERO data. DOEHRS whole counts show that, on average, 790 aviators per year (range 697 to 848) exceed the standard, which requires a follow-up and possible waiver. DOEHRS is most effective for estimating the prevalence of hearing loss, which accounts for approximately 6% of the aviation population. AERO is best used to determine the incidence of new hearing loss in aviators. AERO documented 279 new waivers submitted over three years, averaging 93 waivers per year or about 1% of aviators overall. Even though AERO appears to focus on new waiver submission, it does track waiver continuation, and there appears to be a discrepancy between AERO and DOEHRS. AERO would suggest that there are 746 combined new and previously diagnosed aviators with hearing loss over the three years of 2020 to 2022. This averaged to 249 aviators per year as opposed to the 790 identified over the same time period by DOEHRS. Some of this discrepancy is due to the lag time from when the flight physical is conducted, waiver submitted, and then entered in AERO. DOEHRS is a system where the AOC is self-reported by the patient and manually entered by a technician. The accuracy of the Service Member's AOC is not verified, and manual input can lead to inaccuracies. Lastly, a DOEHRS audiogram is not what is submitted to the flight surgeon for a waiver. Exceeding the standards on the automated hearing test reported to DOEHRS requires an individual to receive a comprehensive diagnostic evaluation completed by a certified audiologist. It is not uncommon for patients to perform better in a one-on-one evaluation than in the group test setting. Additionally, not all aviators are on flight status, which may result in an aviator not completing a flight physical.

## **Discussion**

The presence of hearing loss, outside the current APL standard of C2, appears to be about 6% of the aviator population when analyzing CY 2016-2020. The data looking at asymmetric hearing loss is smaller, with less than 4% presenting with asymmetric loss, as defined by DOEHRS. There does not appear to be a large number of aviators with hearing loss, and few have significant asymmetry within the aviation community in general. It is noteworthy to acknowledge that while hearing loss prevalence may be relatively low, the context is crucial; our research focuses on a community of healthy, active-duty aviators. The integration of hearing protection devices into aircraft communication systems serves as a compelling mechanism for ensuring compliance, resulting in good hearing acuity. Army aviators, subject to yearly flight physicals, recognize the more stringent medical standards they must meet. This may also result in a tendency to comply with hearing conservation measures. All aviators with hearing loss that exceed the APL are required to undergo a comprehensive audiological evaluation. However, the presence of hearing loss does not appear to preclude an aviator from service. Both new and continued waivers are often granted with 100% of continued waiver requests recorded as approved in the AERO system.

The remaining question is, how operationally effective are aviators who present with a hearing loss? Hearing loss, in general, has been shown to be detrimental to the effectiveness of a Soldier (Peters & Garinther, 1990; Price & Hodge, 1976), but individual differences and degree of hearing loss remain uncertain (Sheffield et al., 2017). Although there is little predictive value in pure tones, there is some evidence in the literature to suggest there might be a synergistic relationship between the degree of hearing loss and aviator performance during portions of flight with high workload (Casto & Casali, 2012). The updated DA PAM 40-502 would suggest that 10% of aviators present with audiometric thresholds that may cause a limitation in operational environments. The APL offers guidance that in-flight evaluations should be completed on these individuals; however, these are not standardized and are determined by individual flight surgeons, which can vary. There is no systematic way of assessing, monitoring, or tracking performance on the assigned in-flight evaluations. There remains an operational gap in ensuring that aviators who do not meet APL hearing standards are assessed regarding their auditory functional performance. There is opportunity for this to be completed at the time of the comprehensive audiological evaluation if a flight waiver is required.

The updated DA PAM 40-502 now provides operationally relevant clinical assessments, such as the MOHT, and should be considered in making the determination for acceptable hearing performance rather than relying solely on audiometric thresholds and word recognition in quiet scores. Presenting operationally relevant information to the flight surgeon may provide the information necessary for making decisions in terms of waiver disposition. Given that the completion of the MOHT is driven by Army-wide policy, and assessment is routinely available, it has the potential to fill this operational gap as a non-materiel solution. Implementing this solution would only require the APL to be updated and mirror the DA PAM 40-502 requirements.

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## Appendix A. Acronyms and Abbreviations

AERO	Aeromedical Electronic Resource Office
AOC	Area of Concentration
AAMA	U.S. Army Aeromedical Activity
APL	Aeromedical Policy Letter
AR	Army Regulation
AS	Aeromedical Summary
AWR	Annual Waiver Requirement
C1-C4	Classification or Class 1-4
CY	Calendar Year
DA PAM	Department of the Army Pamphlet
dB HL	Decibel Hearing Level
DI	Disqualified Lacking Complete Information
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOEHRS	Defense Occupational Environmental Health Readiness System
DOEHRS-HC	Defense Occupational Environmental Health Readiness System- Hearing Conservation
DQ	Disqualified
ETP	Exception to Policy
H1-H4	Hearing Profile Level 1-4
Hz	Hertz
ICD-10	International Classification of Disease, 10 <sup>th</sup> Revision
MEPS	Military Entrance Processing Station
MFR	Memorandum for Record
MOHT	Military Operational Hearing Test
MRT <sub>80</sub>	Modified Rhyme Test 80-Word list
MRT <sub>160</sub>	Modified Rhyme Test 160-Word list
MTF	Military Treatment Facility
SD	Standard Deviation
SDT	Spatial Digit Test
SERE	Survival, Evasion, Resistance, and Escape
SM	Service Member
USAARL	U.S. Army Aeromedical Research Laboratory
WRS	Word Recognition Score



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