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SHUTTING Out

Pilots on the flight deck need to hear what they want to hear as much as they need to be protected from what they don't want to hear. While visual information is predominant on flight decks, complete reception and comprehension of spoken words from air traffic controllers and other crewmembers and audio signals from electronic systems are vital to flight safety. Aviation headsets — especially with recent advances in noise reduction and sound attenuation — can enhance a pilot's ability to hear those words and signals throughout flight while also protecting hearing.

Consequences of Noise

Flight deck noise affects both the performance and safety of flight crewmembers, and can induce hearing loss.

Noise on the flight deck affects communication by masking important audio signals. Masking is a process in which one of two simultaneous sounds renders the other impossible to hear. Low frequency noise — the sound produced by the slipstream, for example — masks higher frequency sounds such as an instruction from air traffic control, a crewmember's instructions or an audio warning.

Task performance may be affected by the presence of noise, especially loud noise. Studies suggest that noise reduces a person's overall accuracy and negatively affects the completion of complex tasks[1] — tasks that require attention to a large number of cues presented concurrently or in succession.[2]

Noise can produce a host of reactions in humans. These can be physiological, such as headache, fatigue, nausea and insomnia; psychological, such as irritability, anger and anxiety; or cognitive, such as impaired concentration and decreased ability to estimate elapsed time.

Among the worst consequences of high levels of noise is hearing loss. Noise-induced hearing loss can be either temporary or permanent. A temporary hearing loss is a brief shift in the auditory threshold that occurs after a relatively short exposure to excessive noise — more than 90 decibels (dB). Normal hearing recovers fairly quickly after the noise stops. However, if the noise level is sufficient to damage the tiny hairs in the cochlea — the part of the inner ear that is responsible for transforming sound waves into the electrical signals that go to the brain — the threshold shift can be irreversible, resulting in permanent partial or total hearing loss.

Three Components

On the flight deck, headsets — a considerable improvement over hand microphones and speakers once widely used by pilots — protect hearing and reduce ambient noise while enhancing critical communications.

Nathaniel Baldwin is credited with developing the first basic radio headset

Technological advances have resulted in headsets that enhance communication and protect pilots' hearing.

BY CLARENCE E. RASH

the NOISE

while he was a student at Stanford University in California, U.S., and patenting it in 1910. There was little interest in the device until the eve of World War I, when the U.S. Navy ordered 100 headsets.[3]

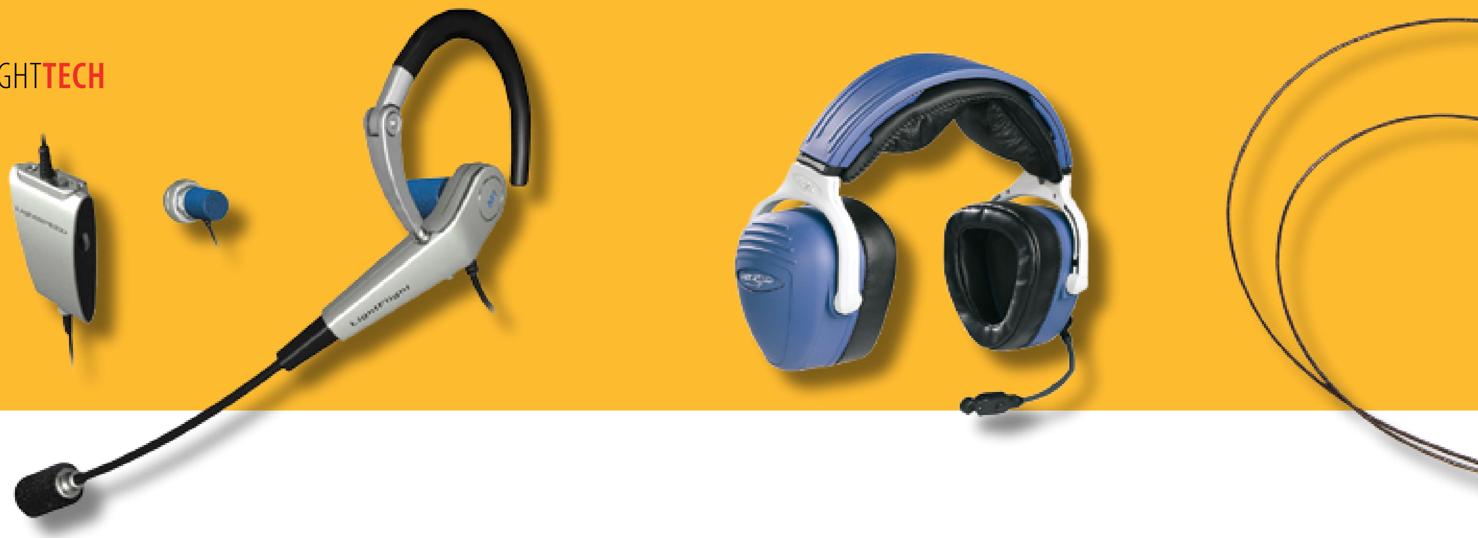
Nearly all headsets have three basic components: a microphone, ear cups or earplugs, and a harness or headband. Most current aviation headsets are classified as either "heavyweights" — which clamp over the user's head, covering both ears — or "lightweights," which resemble personal music earphones. Lightweights, while designed to be more comfortable, typically do not perform as well as heavyweights in blocking out aircraft noise.

Another method of classification is based on the hearing-protection technology incorporated into the headset. The two types of technology currently used are passive noise reduction — or attenuation — and active noise reduction (ANR) — also called electronic noise cancellation.

Conventional passive noise reduction consists of putting something — such as earplugs or earmuffs — in or over the ears to block noise. Properly inserted, standard earplugs typically provide about 30 to 35 dB of protection across the entire noise spectrum. Most modern passive over-the-ears headsets use soft and flexible cushions to form a good seal, preventing ambient noise from directly entering the ear and providing 20 to 30 dB of protection, which is most effective at higher frequencies. Anything that interferes with the seal, such as sunglass or eyeglass temples, compromises the noise-protection level. Sounds are conducted toward the ear when sound waves — such as the relatively high-frequency sound waves produced by voices or audio signals — hit the outer ear cup and cause the cup to vibrate; this, in turn, causes the air inside the cup to vibrate. Low-frequency sound waves such as those produced by the slipstream do not have enough energy to make the cup vibrate and therefore are not heard.

ANR, first conceived in the 1930s and refined in the 1950s, did not become prevalent in aviation until the 1990s.[4] In conventional ANR headsets, the frequency and amplitude of the sound inside the headset cavity are measured by a small microphone, and a 180-degree out-of-phase copy is produced and fed back into the headset; the two signals superimpose and cancel each other.

Regardless of the type of feedback loop used, in order for ANR headsets to perform their task, they require electrical power from either a battery pack or the aircraft. The ANR technology is generally effective only at lower frequencies. A protection level of 20 dB over this lower frequency range is typical. This makes this type of headset most effective in environments such as aviation, where the noise spectrum consists of mostly lower frequency



sounds.[5] ANR headsets also provide signal-to-noise improvement — clear sounds — by reducing the masking effects of low-frequency noise.

However, ANR is not a one-size-fits-all system. Every pilot has a different hearing response. Therefore, the perceived performance of a selected ANR headset varies from pilot to pilot. Ultimately, the best method of evaluating the effectiveness of an ANR device is for the pilot who plans to use it to try it out in the aircraft that he or she usually flies.

ANR aviation headsets were developed to cancel the lower frequency sounds produced by piston engines and propellers. Because turbine engines typically produce sounds in the mid- to high-frequency ranges, ANR headsets designed for use in piston aircraft will be less effective in turbine aircraft. Ideally, a detailed knowledge of the noise spectrum of the specific aircraft, compared with the performance of the ANR headset, will allow each pilot to choose the ANR device that is best for him. Unfortunately, the noise spectrum pattern produced by a specific aircraft is rarely available.[6]

The U.S. Federal Aviation Administration (FAA), as well as many hearing-protection organizations, recommend a dual protection approach, using both earplugs and a headset.[7] However, the use of earplugs under a headset is somewhat counter-productive; the earplugs impede a pilot's ability to hear headset communications. An approach that provides the extra protection of the earplug without compromising communication is the communication earplug (CEP).

The CEP, which initially was developed for use in U.S. Army helicopters, provides the high-quality hearing protection of an expanding foam earplug while allowing clear passage of speech communication to the ear. A miniature speaker and foam earplug are coupled to yield a lightweight communications device that can be used alone or in combination with over-the-ear hearing protection. The CEP, when worn in combination with other hearing protection, reduces noise exposure to minimal levels.

Tests conducted by the Army showed reductions of "more than 30 dB for the low frequency noise spectra that are prevalent in helicopters," said Ben Mozo of Communications and Ear Protection Inc., developer of the device.

Selection Criteria

A quick survey of the market reveals more than 25 manufacturers offering more than 100 different aviation headset models that range in price from about US$100 to more than $1,000.

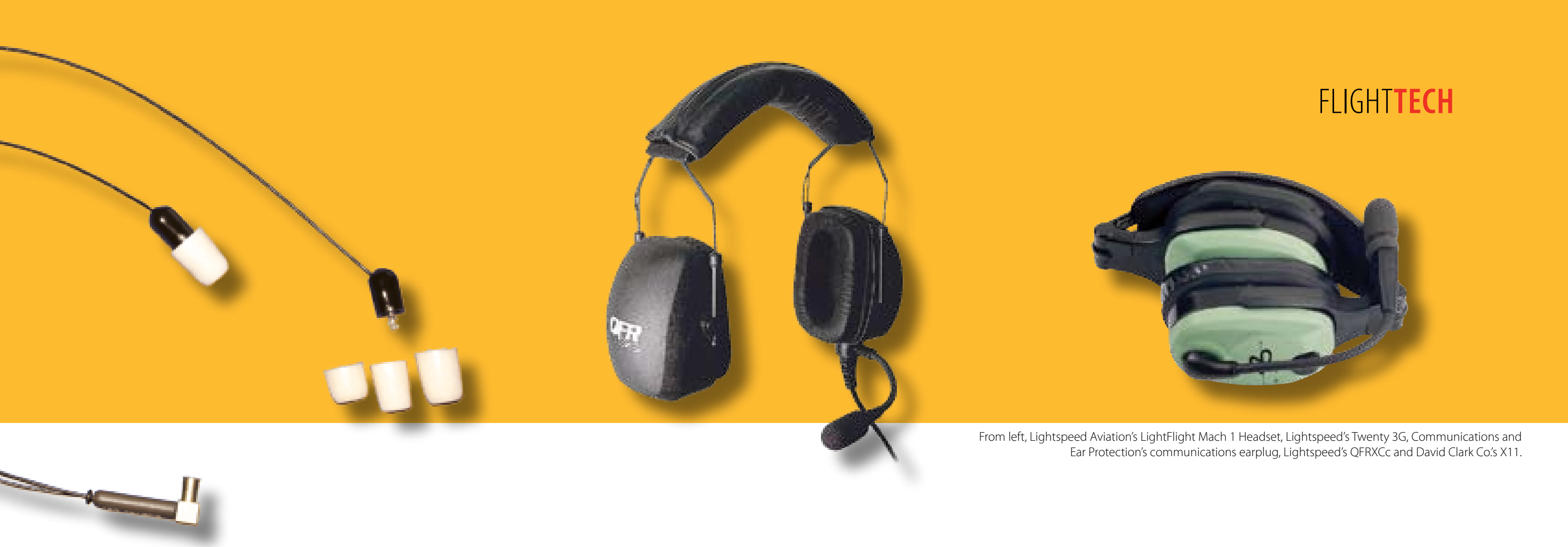
In addition to price, headset selection criteria can be separated into performance, comfort and added features.

For performance, the first decision is active or passive noise reduction. At about twice the cost, ANR headsets are considered superior to passive noise reduction systems. Nevertheless, performance depends greatly on the ability of the headset ear cups to seal over the ear. A label should disclose the headset's protection level — a noise reduction rating of at least 24 dB is recommended (see "Rating Systems").

Although the FAA does not regulate headsets, it does provide specification guidance in two technical standard orders (TSOs).[8,9] Many of the specifications discuss construction and environmental criteria for the manufacturer rather than operating and protection performance criteria for the user. Nevertheless, headsets that meet these specifications bear the applicable TSO marking — and this should be a factor in the selection process.

Another performance factor is how a headset receives its power. A headset that can be operated with either battery power or aircraft power is a plus.

In addition to active/passive technology, overall comfort should be considered. Weight and "feel" — that is, clamping pressure and headband/strap design — determine how comfortable a headset will be, especially after several hours of flight. Headset weights typically are about 12 to 18 ounces (340 to 510 grams); a difference of a few ounces may not seem worth worrying about, but over a long period, the extra weight can induce neck strain and headache.



From left, Lightspeed Aviation's LightFlight Mach 1 Headset, Lightspeed's Twenty 3G, Communications and Ear Protection's communications earplug, Lightspeed's QFRXCc and David Clark Co.'s X11.

Clamping pressure and the headband/strap mechanism also are important considerations. All headsets of reasonably good quality have some type of adjustment to permit expansion or tightening of the ear cups. The amount of padding on the ear cups and headband/strap is a strong indicator of how comfortable the headset will be.

Finally, if possible, the pilot should test the headset in the aircraft that he or she usually flies.

Most headsets offer additional features. One option is a choice of ear seals made of foam plastic or newer surgical gels, which manufacturers say are more effective in distributing the pressure of the ear seals against the head. Another is a choice of stereo or monaural speakers, or individualized speaker controls on each headset ear cup to allow for independent adjustment of the volume for each ear. However, the stereo option is useless if the aircraft's audio system does not support stereo outputs.

As with most electronic equipment, keeping a headset in good working order requires regular preventive maintenance. Exterior parts should be cleaned regularly with mild soap and water, and dried well before use. Periodic inspections should be conducted to check for cracks on ear cup seals and missing parts, and to ensure that headband tension is sufficient. Parts that have hardened or cracked and those that cannot be cleaned should be replaced. ●

Rating Systems

One method of rating the protection level provided by hearing protection devices is the noise reduction rating (NRR) system specified by the U.S. Environmental Protection Agency. It is the measure, in decibels (dB), of how well a hearing protector reduces noise; the higher the number, the greater the noise reduction.

When dual protectors are used, the combined NRR is usually accepted as 5 dB more than the higher rating of the two devices. For example, if a pair of earplugs with an NRR of 25 dB is worn under earmuffs with an NRR of 23 dB, the NRR of the combination is 30 dB (25 dB + 5 dB = 30 dB).

Additional protection rating numbers are in use throughout the world. These include the single number rating (SNR) system defined by International Organization for Standardization in ISO/DIS 4869-2.2.

— CER

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