ANALYSIS OF HEARING THRESHOLD SHIFTS AMONG ASTRONAUTS ON LONG-DURATION MISSIONS
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INTRODUCTION
Given that numerous sources of high levels of noise exist on long-duration missions on the International Space Station, crewmembers have been considered to be potentially at risk for temporary or permanent noise-related reductions in hearing sensitivity. To monitor their hearing thresholds, crewmembers undergo a series of audiometric tests in preflight, inflight, and post flight exams in order to identify any indication of decrements in high frequency hearing sensitivity (the customary manifestation of noise-related hearing loss). Using conventional audiometry (performed in a clinic), post flight hearing thresholds are compared to preflight (baseline) hearing thresholds, to determine if any “Mission-Associated Significant Threshold Shift” (m-STS) is indicated in high frequency regions (2000-4000 Hz), which would be consistent with conventional occupational hearing loss program protocols. Hearing sensitivity is also monitored inflight using NASA’s unique On-Orbit Hearing Assessments (OOHA) during each ISS increment, using similar criteria. These reviews have revealed relatively few instances of high frequency m-STS, yet a surprisingly high incidence of “Low Frequency Mission-Associated Significant Threshold Shift” (lfm-STS), which is not expected after exposure to high noise. This finding warrants closer examination, since auditory sensitivity in low frequencies is known to be affected by increased stiffness properties in the peripheral auditory system, including the cochlea (e.g., with increased hydraulic pressure within the inner ear endolymphatic system, caused by endolymphatic hydrops). Identification of lfm-STS and analysis of OOHA data are worthwhile at this time, since there are communications between intracranial and cochlear fluids. As investigators at this workshop know, NASA has become earnestly focused on the effects of increased intracranial pressure among ISS crewmembers. The purpose of this retrospective study is to examine the unique set of audiometric and OOHA data acquired from ISS crewmembers, in order to identify characteristics that might point to relationships between inflight hearing changes and increased intracranial pressure. If the prevalence of lfm-STS can be identified in subgroups of crewmembers (e.g., those who have shown signs of vision impairment and elevated intracranial pressure, those who did their OOHA in “quiet” environs of the ISS, or examination of male/female differences), our existing OOHA data can offer new information that has not yet been reported.

METHODS
This study is a retrospective review and analysis of audiometric data and OOHA data collected from male and female U.S. crewmembers from Increments 1-37. Air conduction audiometry was performed in the Johnson Space Center Clinic, using conventional clinical audiometric techniques and equipment, including a sound-treated audiometric booth. The OOHA was performed by the crewmember on the ISS, using a method of adjustment technique, 14 days after launch and then every 45 days thereafter. The stimuli are generated by a program on the Space Station Computer, and routed via its sound card to a pair of high-fidelity silicone ear monitors that are custom-made for each crewmember. An active noise reduction headset is worn over the monitors and the test is done in one of the station’s quietest areas. All data are analyzed on the ground by an audiologist and other medical personnel. The specific metrics measured in this study were:

1. Analysis of incidence of m-STS and lfm-STS, using audiometric data acquired preflight and post flight.
2. Analysis of incidence of m-STS and lfm-STS, using OOHA data acquired inflight, including changes seen in successive OOHA s during the mission.
3. Comparison of m-STS data to acoustic dosimetry measurements of crew noise exposures obtained during the mission.

DISCUSSION
Preliminary analyses of inflight OOHA results suggests that 51% of inflight OOHA s showed an lfm-STS of 10 dB or more in low frequencies of 250 and 500 Hz, but an incidence of m-STS (in high frequencies) of less than 2%. Inter-test variabilities were observed (common in psychophysical techniques used in audiometric testing) and accounted for in determining whether a “change” was significant. This study may yield useful information about 1) clinical factors that affect repeatability and reliability of OOHA testing and audiometry, 2) relationships between lfm-STS and crew demonstration of increased intracranial pressure and 3) relationships between OOHA and audiometric results and the noise exposures reported on the crewmember’s ISS mission.