Development Efforts of In-Ear Exposure Sensors (IEES)

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INTRODUCTION

According to the Department of Defense, there were more than 400,000 known TBI diagnoses in service members between 2000 and 2019 (DVBIC, 2020). Detection and measurement of potential injury due to blast overpressure and blunt impact have been priorities of the US military for many years, especially since Operation Enduring Freedom. Among those deployed, estimated rates of probable TBI range from 11–23%. We now know that diffuse brain injuries are caused by excessive brain deformation and are generated by rapid rotational head motion (Gabler, Crandall, & Panzer, 2018). This breakthrough in injury mode has spotlighted the importance of recording accurate 6DOF head motion when setting safety standards regarding the training and operational requirements of service members.

Military Operational Environment Examples

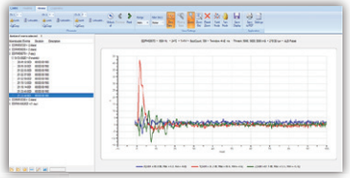
In military environments, maintaining Auditory Situational Awareness (ASA) and providing protection from hearing hazards are often dueling priorities. Traditional passive hearing protection devices can provide adequate protection to the soldier from impulsive and continuous noise hazards, but this can come at the cost of reduced ASA. Anecdotal reports indicate that many soldiers may forego passive hearing protection use entirely in an attempt to maximize ASA. According to an annual benefits report released in 2012 by the Department of Veterans Affairs, the most prevalent service-connected disabilities for veterans receiving federal compensation in 2011 were tinnitus and hearing loss.

Diversified Technical Systems (DTS) and the University of Virginia Center for Applied Biomechanics (UVA CAB) were awarded an STTR, Topic No. DHA20B-002, "In-Ear Exposure Sensor (IEES) with Integrated Noise Attenuation and Communications Capabilities". The goal of the STTR is to combine the need for a hearing protection system with sensing technology to create a dosimeter capability for 6DOF head motion, blast overpressure and gunfire hearing exposure monitoring.

DTS INNOVATIONS

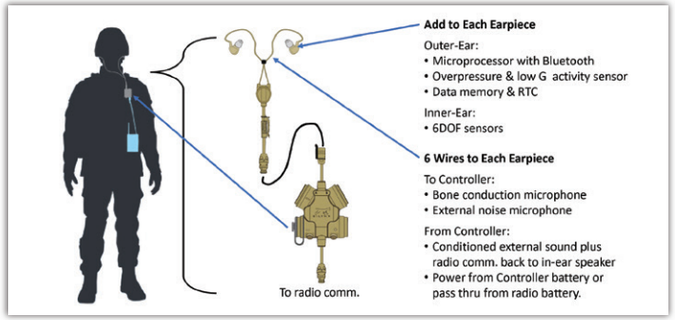
In 2017 DTS was contracted by the NFL (National Football League) to develop a new dosimeter and sensing technology. Commercially available sensors had sampling rates and bandwidth frequencies too low to accurately measure concussive events at the NFL level. Current sensors' power draw also required relatively large batteries. It was clear that a new, innovative sensing technology was needed.

Commercial, low cost sensing technologies often combine MEMS sensing elements with integrated signal conditioning and analog to digital conversion circuits to create "digital" sensors. Unfortunately, most of these sensors were designed for the broader "wearables" market and don't have the range, bandwidth and accuracy needed for human impact biomechanics measurement. DTS partnered with ADI (Analog Devices) to create a new class of linear and angular accelerometers to meet performance, power and size required for a 6DOF mTBI measurement.



Dynamic Data Recorder Development

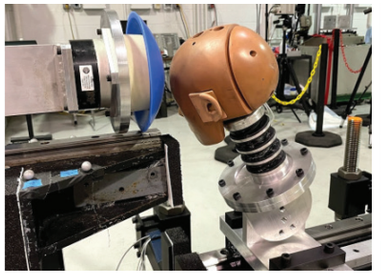
The IEES STTR effort has focused on using the 6DOF sensor technology from the NFL work to create an in-ear dosimeter package, that also includes ambient and over-pressure noise sensors, integrated in to a noise canceling headset.

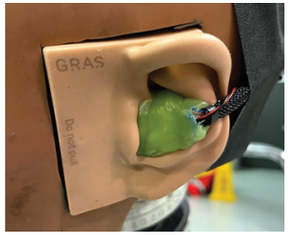


RESULTS

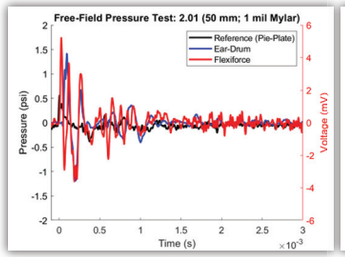
As a part of the DHA STTR effort, DTS created a prototype sensor system with 6DOF and sound/pressure sensors. The IEES prototype was tested at the UVA CAB laboratories in blunt impact and blast tube scenarios. Goals of the testing included:

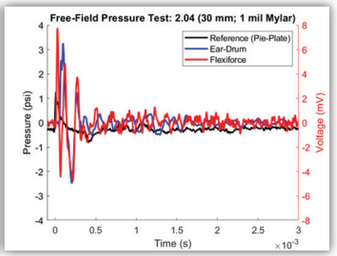
- Determine the prototype sensors' ability to accurately measure 6DOF head motion while mounted in a surrogate ear-form attached to a H3 headform.
- Evaluate the sound/pressure sensors' dynamic range to measure from gunfire (~0.5 psi) to blast (~30 psi) pressure levels.





IEES Prototype Testing





CONCLUSION and FUTURE

Through funding of an SBIR contract through the Defense Health Agency, DTS has developed a new, innovative 6DOF and blast dosimeter that is much smaller and more accurate than any other system. Testing of this device has proven that the prototype is able to both recognize and capture blast even at <1psi, which is a range not often captured by other devices. This dosimeter device, can be powered by a hearing aid battery and weighs <3g can be integrated with other protective equipment like helmets, footwear and tactical headsets while remaining unobtrusive to the wearer.

Groundbreaking in-ear dosimeter will capture overpressure and impact events.