

Improved Hearing Protection from Non-Invasive Ear Scans

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PROBLEM STATEMENT

Noise induced hearing loss is a problem throughout the military and heavy industry. Hearing loss reduces quality of life for those affected. For warfighters, reduced hearing function can also contribute to reduced mission effectiveness.

Flight deck and other warfighter personnel who work in loud noise should wear protective equipment to reduce their risk of ear damage. Earplugs are a common form of protective equipment. Earplugs that are custom fitted to an individual's ears can provide significant protection from noise.

A major challenge to fielding custom earplugs is the process of measuring the ears, of flight deck and other warfighter personnel, for custom fitting earplugs. Unfortunately, today's baseline technology for measuring ears – taking a physical ear canal impression – is slow, expensive, unpleasant, and poses a significant logistical burden for storing, and subsequently accessing, these custom ear impressions.

To meet this need, Adaptive Technologies, Inc. has developed an accurate, efficient, robust system, which digitally – and for the person being measured, comfortably – captures ear canal geometries, eliminating the need for acquiring physical ear canal impressions.

Customers and manufacturers can then share, archive, access, and manipulate those digital datasets to provide custom earplug products with a minimized logistical burden.

WHO CAN BENEFIT?

Navy flight deck maintainers will be the first beneficiaries of this technology. Working in close proximity to today's military aircraft, some of the loudest machines ever built, puts the maintainer population at considerable risk of hearing loss. Conscientious use of advanced personal protective equipment is critical to ensuring continued safety of the flight deck workforce.

Initial customers will be program managers responsible for supplying protective equipment to flight deck personnel. Customers who use this technology as part of an effective hearing conservation program will benefit from up-front cost savings on ear measurements. Flight deck and warfighter personnel utilizing hearing protection produced using this system will be healthier and more effective, and reduce hearing-related disability obligations in the future.

Subsequent customers will be from the many military and industrial organizations whose personnel work in noisy environments. Our ear measurement system can also benefit manufacturers of custom earplug products as it is often the manufacturer who is tasked with collecting the requisite measurements.

BASELINE TECHNOLOGY

Making custom earplugs traditionally requires measuring ears by way of physical ear canal impressions. An ear impression is formed by injecting liquid rubber into the ear, waiting for the liquid to cure into a solid, and then removing the solid to show the inside shape of the ear. Manufacturers use the shape of the solid impression to design the custom earplug.

For personnel being measured, getting ear impressions can be uncomfortable and there is some risk of injury. For manufacturers, collecting, shipping and storing ear impressions is expensive and time consuming. For organizational customers, scheduling and supporting ear impression collection is often a logistical burden.

TECHNOLOGY DESCRIPTION

This technology simplifies custom earplug deployment by eliminating the need for physical ear canal impressions. Our system uses a mobile, low-dose Volume Computed Tomography (VCT) scanner to measure ears quickly and non-invasively. Instead of physical ear canal impressions, a person being measured simply sits while the scanner rotates around their head. Scanning takes only 20 seconds and then software extracts the ear shapes from the scan data. The measurement process is comfortable and the digital output can be stored and transferred to manufacturers, electronically. Significant cost and manpower savings are possible as compared to using the traditional process. While the

scanner does use small amounts of radiation, the risks are low and equivalent to those of a full dental workup. This technology also eliminates the injury risk associated with physical ear canal impressions.

Adopters of this technology will be able to better protect the hearing, and thus mission effectiveness, of their personnel by deploying custom earplugs faster, at less cost, with minimized logistical burden, and more comfortably than is otherwise possible today. Having better hearing protection available will help to reduce the incidence of hearing loss.

For program managers looking to obtain ear measurements to outfit their personnel with high performance custom hearing protection, this new system is easy to implement, offers a more pleasant personnel experience, and is expected to produce the same quantity of manufacturing-ready digital ear measurements for 50 percent of the cost. Table 1 summarizes the most significant benefits of this new system.

Table 1: Features, Advantages, and Benefits of Non-Invasive Ear Scans

Feature	Advantage	Benefit to Customer
Digital Ear Scan measurements	<ul style="list-style-type: none"> • Quick and non-invasive • Eliminates ear impressions 	<ul style="list-style-type: none"> • Scanning is comfortable • No risk of ear canal injury
High Throughput (100 measurements per day from one scanner)	<ul style="list-style-type: none"> • Requires a two-person staff to collect 100 measurements • Traditional ear impression collection requires 6 personnel 	<ul style="list-style-type: none"> • Reduced labor expenses • Reduced travel expenses
All Digital Output	<ul style="list-style-type: none"> • Measurements transmitted to manufacturers electronically • Eliminates shipping and storing of ear impressions 	<ul style="list-style-type: none"> • Reduced shipping costs • Products are ready faster • Digital data is easier to save • Easy reorders
20-second Scan Time	<ul style="list-style-type: none"> • Exceptionally fast system • Including paperwork, scan visit takes <5 min vs. >15 min 	<ul style="list-style-type: none"> • Reduced labor expenses • Requires less personnel time, maintaining productivity
Low Dose Ear Scan (0.18 mSv / measurement)	<ul style="list-style-type: none"> • Radiation dose is less than a full dental workup 	<ul style="list-style-type: none"> • Very low exposure risk • Personnel safety • Customer peace of mind
Scanner uses 110VAC, 40" x 36" footprint	<ul style="list-style-type: none"> • System can be installed in an office, without special wiring • Small footprint is suitable for mounting in a mobile van 	<ul style="list-style-type: none"> • Flexible installation options • System can be tailored to specific customer needs

CURRENT STATE OF DEVELOPMENT

This non-invasive ear scanning system is currently at Technology Readiness Level (TRL) 5. The major system components, VCT scanner and earshape extraction software, have been demonstrated to work together and have been used to produce high performance custom earplugs. Ongoing development is focused on upgrading the scanner hardware and adding automation to serve high-volume applications. Real Ear Attenuation Testing

(REAT) is also scheduled and will document that the performance of earplugs created from scans matches that of earplugs built from traditional physical ear canal impressions. Achieved and projected milestones for this SBIR project are summarized in Table 2 below.

Table 2: Technology Development Milestones

Milestone	TRL	Risk	Measure of Success	TRL Date
Concept Validation	5	Low	Demonstrate recording earshapes, non-invasively, by VCT scanner	Feb. 2009
Business Case	5	Low	Analysis shows a positive return on investment for using this system	Nov. 2009
System Enhancement	6	Low	Demonstrated capability to measure left and right ears with a single scan, for faster throughput	Mar. 2011
Qualification	6	Low	REAT shows performance of earplugs created using this system meets that published for traditional approach	Mar. 2012

REFERENCES

NAVAIR Technical Point of Contact
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2nd Technical Point of Contact
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WHEN THE TECHNOLOGY WILL BE READY FOR USE

By March 2012, this ear measurement system will be at TRL 6 and ready for validation in an operational environment. Adaptive Technologies Inc. is seeking interest from Department of Defense (DoD) acquisition programs, with needs to deploy significant quantities of custom hearing protectors, to endorse SBIR Phase II.5 or program office Phase III funding for a staged pilot program demonstration. The first stage of the pilot will demonstrate measuring ears by VCT scan from a mobile platform in an operational environment. The second stage will demonstrate full production throughput of the mobile scanning system. Both stages of the pilot are targeted for completion within the fourth quarter of 2012. Following successful pilot program demonstrations, this system will be at TRL 7.

ABOUT THE COMPANY

Adaptive Technologies, Inc. (ATI) is a small business located in Blacksburg, Virginia. ATI provides research and development, design and engineering, and consultation on products and problems associated with noise control, hearing protection, signal

processing, and control theory. Since 1997, ATI has completed numerous consulting contracts for industry and government including SBIR Phase II awards for each of the major DoD agencies. ATI holds key patents on digital earplug and microphone technologies and licenses manufacturing rights for new products to Aegisound, LLC. Aegisound is an affiliated, ISO 9001:2008 certified, HubZone manufacturing company, also located in Blacksburg, Virginia. ATI's world class expertise and patented products offer communication solutions to problems involving dangerously high noise levels. We are dedicated to advancing the science of hearing protection and improving combat and civilian communications.

ATI also offers a number of organizational advantages. Our research and development staff work closely with new product development engineers to generate effective, and practical, solutions. New technologies are brought to market quickly through strategic partnerships and an affiliated manufacturing company, Aegisound. ATI is entirely U.S. based and has a flat organization to provide clients with fast and easy access to technical team members. ATI also operates within an ISO 9001:2008 certified quality system.