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FIT-EAR™ MPD and VS-1 Earpiece Operational Field Assessment Report

November 2011

Prepared for:

TechSolutions Program
Department of Homeland Security
Science and Technology Directorate
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First Responder Technologies (R-Tech)
Field Assessment Program

FIT-EAR™ MPD and VS-1 Earpiece
Operational Field Assessment Report

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Science and Technology

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EXECUTIVE SUMMARY

In support of the TechSolutions Program within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T), Science Applications International Corporation (SAIC) conducted an independent and comprehensive operational field assessment of the commercially available Fit-Ear™ Multi Purpose Device (MPD) and Vented Stereo (VS-1) communication enhancing earpieces. The purpose of the field assessment was to provide an opportunity for firefighters to test and evaluate the effectiveness of the MPD and VS-1 during simulated emergency response operations to determine if they would be valuable tools for the firefighting community.

The MPD and VS-1 earpieces are molded to the individual user for a custom fit. Prior to the field assessment, Fit-Ear obtained molds of each firefighter who had volunteered to be a test subject, and then provided the custom earpieces at the assessment. Additionally, Fit-Ear provided training and familiarization on the earpieces to the test subjects at the beginning of the assessment.

The field assessment was executed on October 5, 2011, at a firefighting training facility at Aberdeen Proving Ground (APG) in Aberdeen, Maryland, with the assistance of the APG Fire Department. The results of the field assessment are based on the cumulative opinions of the test subjects, which were recorded throughout the assessment.

The results of the field assessment indicate that the MPD is highly efficient in providing clear communication and reducing background noise and can be effectively utilized with firefighting turnout gear. The overall opinion of the test subjects is that the MPD provided them the best communication enhancement they have ever experienced and that the firefighting community would benefit from the technology. In addition, the test subjects believe that the increase in clear communication with less background noise raises the level of safety for the firefighter. The test subjects also provided valuable recommendations to enhance the usability of the MPD.

The results of the field assessment for the VS-1 indicate that it provides good hearing protection by reducing background noise and the vented design, which allows amplified ambient sound to be heard, would be beneficial in certain applications. In the opinion of the test subjects, the VS-1 is an improvement from current hearing protection devices such as foam inserts and would be more valuable used as hearing protection when ambient communication is important.

For both the MPD and VS-1 earpieces, the test subjects provided positive comments on the comfort of the custom fit and the ease of use. Their main concern was that the high cost of the earpieces may prevent jurisdictions from being able to outfit all the firefighters within each department.

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1. INTRODUCTION

The TechSolutions Program within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) provides valuable information, resources, and technology solutions to address mission capability gaps identified by the emergency response community. TechSolutions personnel learned about the Fit-Ear™ Multi Purpose Device (MPD) and Vented Stereo (VS-1) earpieces, which may provide firefighters with a communication enhancement device that reduces external background noise during firefighting operations. Therefore, TechSolutions worked with personnel from Fit-Ear and representatives from a local fire department to conduct a test of this device under simulated operational conditions to determine its performance in typical noise environments.

The National Fire Protection Association (NFPA) publishes NFPA 1561, *Standard on Emergency Services Incident Management System*, which states: "To enable responders to be notified of an emergency condition or situation when they are assigned to an area designated as immediately dangerous to life or health, at least one responder on each crew or company shall be equipped with a portable radio, and each responder shall be equipped with either a portable radio or another means of electronic communication." Firefighters, however, have identified the difficulty in communicating during firefighting operations due to high levels of background noise produced by firefighting equipment and the barrier imposed when donning personal protective equipment (PPE). The Fit-Ear MPD and VS-1 earpieces are designed to increase the ability of firefighters to understand emergency response communication transmitted through communication systems, such as a Motorola™ XTS® 5000 radio.

In support of the TechSolutions Program, Science Applications International Corporation (SAIC), under contract with DHS S&T (General Services Administration [GSA] Schedule Number GS-23F-0107, Order Number HSHQDC-10-00128), provided an independent test and evaluation of the Fit-Ear MPD and VS-1 earpieces. This report outlines the results of the operational field assessment, which are presented as observations and do not imply success or failure of the technology.

2. DESCRIPTION OF TECHNOLOGY

The MPD earpiece (figure 2-1) is a digital electronic hearing enhancement earpiece that includes an internal amplifier and a protective device that reduces background noise up to 32 decibels (dBA) to enhance communication between users. The earpiece is custom molded to the individual user. The amplifier and battery are located internally in the earpiece. The volume control allows for sensitivity adjustment and is located in the cord connecting the earpiece to the radio, thereby eliminating the need to use the radio volume control. The retail cost for one set is $1,650. Refer to table 2-1 for MPD specifications.

Photo provided courtesy of Fit-Ear™

Figure 2-1. Fit-Ear™ MPD Earpiece

Table 2-1. Fit-Ear™ MPD Earpiece Specifications

Specification	Measurement[1]
Sensitivity	114 dB SPL @ 1 kHz
Impedance	26 ohm @ 1 kHz
Frequency range	40 Hz-18 kHz
Noise reduction	-32 dBA[2]

Notes:

1. Measurements were provided by Fit-Ear and have not been verified by SAIC.
2. Fit-Ear products are not meant to block out all sound, but to provide limited noise protection from loud environments and still allow a person to communicate, depending on the hearing loss of an individual.

dB = decibel
dBA = decibel level for the human ear
kHz = kilohertz
Hz = hertz
SAIC = Science Applications International Corporation
SPL = sound pressure level

The VS-1 earpiece (figure 2-2) provides hearing protection by reducing background noise up to 21 dBA, and the vented design allows limited ambient sound to enter the earpiece for enhanced external communication. An internal amplifier powered by a battery raises the volume of the ambient sound entering the earpiece. The earpiece is custom molded to the individual user. The VS-1 is not designed to enhance communication transmissions directly from a radio. The retail cost for one set is $1,000. Refer to table 2-2 for VS-1 specifications.

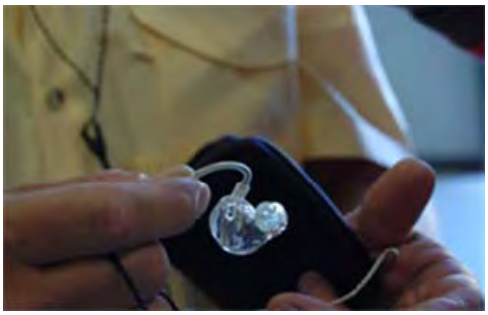

Photo provided courtesy of Fit-Ear™

Figure 2-2. Fit-Ear™ VS-1 Earpiece

Table 2-2. Fit-Ear™ VS-1 Earpiece Specifications

Specification	Measurement[1]
Noise reduction	-21 dBA[2]

Notes:

1. The measurement was provided by Fit-Ear and has not been verified by SAIC.
2. Fit-Ear products are not meant to block out all sound, but to provide limited noise protection from loud environments and still allow a person to communicate, depending on the hearing loss of an individual.

dBA = decibel level for the human ear
SAIC = Science Applications International Corporation

3. FIELD ASSESSMENT EXECUTION

The reduction of background noise was a key element in the successful performance of the MPD and VS-1 earpieces at the field assessment. Section 3-1 briefly describes regulations regarding decibel exposure, the noise levels normally experienced by firefighters, and the performance of the earpieces in noise reduction at the assessment.

3.1 Understanding Sound Decibels

The decibel (dB) is a measurement of sound that can be heard by the human ear. Loudness doubles with every increase of 10 decibels. The decibel is used for a wide variety of

measurements in science and engineering, most prominently in acoustics and electronics. The decibel symbol is often qualified with a suffix that indicates which reference quantity or frequency weighting function has been used. For example, A-weighted decibels, abbreviated dBA, indicate that the reference quantity is for human hearing.

Firefighters are subjected to loud sounds produced by vehicles and equipment, which often reduce their ability to communicate clearly. Understanding the decibel level of the sounds produced while performing their tasks during operations will assist in ensuring that firefighters are adequately equipped with proper hearing protection when needed and that communication devices are capable of performing as required. Table 3-1 provides a snapshot of the sound thresholds in dBA.

Table 3-1. Hearing Comfort Scale

Comfort Level	dBA
Hearing Threshold	0
	20
Conversation	40
	60
Discomfort	80
	100
Pain Threshold	120
	140

Note:

dBA = decibel level for the human ear

The Occupational Safety and Health Administration (OSHA) regulation 1910.95 states that when employees are subjected to sound exceeding those listed in table 3-2, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within these levels, PPE shall be provided and used to reduce sound levels to within the levels of the table.

Table 3-2. Maximum Daily Noise Exposure (OSHA)

Daily Noise Exposure (Hours)[1]	dBA
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Notes:

1. When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered rather than the individual effect of each. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

dB = decibel
dBA = decibel level for the human ear

Decibel measurements were obtained by SAIC at the field assessment using a Sper Scientific Type 2 digital sound level meter (model 840029), as shown in figure 3-1. The meter complies with American National Standards Institute (ANSI) S1.4, *Standard Specification for Sound Level Meters*. This standard sets performance and accuracy tolerances according to three levels of precision: Types 0, 1, and 2. Type 0 is used in laboratories, Type 1 is used for precision measurements in the field, and Type 2 is used for general-purpose measurements. For compliance purposes, readings with an ANSI Type 2 sound level meter are considered to have an accuracy of ±2 dBA, while a Type 1 instrument has an accuracy of ±1 dBA. A Type 2 meter is the minimum requirement by OSHA for noise measurements and is usually sufficient for general-purpose noise surveys. The Sper Scientific sound meter includes an internal calibration system. Prior to the assessment, SAIC calibrated the meter using a special calibration tool and instructions provided by the manufacturer.

Figure 3-1. SAIC Measures Decibel Levels During Assessment

Table 3-3 lists the decibel ranges of noises recorded by SAIC at the field assessment. The columns that list the dBA range information for the Fit-Ear MPD and VS-1 earpieces are based on the manufacturer's provided specifications and were not verified at the assessment.

Table 3-3. Assessment Decibel Levels

Noise Source	dBA Range[1]	dBA Range Using MPD[2]	dBA Range Using VS-1[2]
Building internal background noise (no equipment operating)	75-79	43-47	54-58
Building fire alarm at alarm control box	96-100	64-68	75-79
Chain saw cutting wood on building roof (gas powered)	95-108	63-76	74-87
Charged nozzle (solid stream) at building entrance (1-1/2-inch hose)	78-80	46-48	57-59
Charged nozzle (fog) at building entrance (1-1/2-inch hose)	80-82	48-50	59-61
Charged nozzle (solid stream) against room walls (1-1/2-inch hose)	95-97	63-65	74-76
Charged nozzle (fog) against room walls (1-1/2-inch hose)	85-87	53-55	64-66
Charged nozzle (solid stream) against simulated vehicle (1-1/2-inch hose)	79-90	47-58	58-69
Charged nozzle (fog) against simulated vehicle (1-1/2-inch hose)	78-86	46-54	57-65
Combination tool cutting and spreading metal (gas powered)	79-86	47-54	58-65
Concrete/steel saw cutting steel tank (gas powered)	97-113	65-81	76-92

Table 3-3. Assessment Decibel Levels (Continued)

Noise Source	dBA Range[1]	dBA Range Using MPD[2]	dBA Range Using VS-1[2]
Electrical truck siren	120-122	88-90	99-101
Electro-mechanical truck siren	121-127	89-95	100-106
Exhaust fan at building entrance (gas powered; positive pressure)	94-97	62-65	73-76
External background noise (light roadway construction in the distance)	60-67	28-35	39-46
Fire truck pump station (operating at 120 psi)	90-92	58-60	69-71
Fire truck generator	95-97	63-65	74-76
Fire truck in motion	75-80	43-48	54-59
Hose (nozzle off) carried to second floor via stairwell	52-70	20-38	31-49
Personal Alert Safety System (PASS) (integrated with SCBA)	92-97	60-65	71-76
SCBA Air-Pak®	54-75	22-43	33-54
Air horn	119-121	87-89	98-100

Notes:

1. Decibel range includes equipment from idle to peak operation.
2. Measurements provided by the manufacturer were not verified at the assessment.

dBA = decibel level for the human ear
MPD = Multi Purpose Device
PASS = Personal Alert Safety System
psi = pounds per square inch
SCBA = self-contained breathing apparatus
VS = Vented Stereo

3.2 Human Subject Research

In accordance with federal regulations, research involving human subjects must be reviewed by an Institutional Review Board (IRB) before the research can begin. The purpose of an IRB review is to ensure, both in advance and by periodic review, that appropriate steps are taken to protect the rights and welfare of humans participating in a research study. To accomplish this purpose, the IRB reviews research protocols and related materials (e.g., informed consent documents) to ensure protection of the rights and welfare of human subjects as outlined in the Code of Federal Regulations (CFR), Title 45 CFR Part 46. The chief objectives of every IRB protocol review are to assess the ethics of the research and its methods, to promote fully informed and voluntary participation by prospective subjects who are themselves capable of

making such choices, and to maximize the safety of subjects once they are enrolled in the project.

SAIC is a parent organization for an IRB, which is registered with the Office for Human Research Protections (OHRP) under the U.S. Department of Health and Human Services (DHHS). An application package was submitted on the Fit-Ear project to the SAIC IRB, and initial approval was granted in writing (appendix A) to continue the research based on that application. Note: The Fit-Ear project was granted quarterly approvals to continue.

3.3 First Responder Participation (Test Subjects)

Four firefighters actively engaged in fire departments volunteered to serve as the firefighting community proxy for the Fit-Ear MPD and VS-1 operational field assessment. The firefighters, herein referred to as test subjects, were solicited based on their experiences in firefighting and emergency response procedures. Table 3-4 highlights their experiences.

Table 3-4. Test Subject Demographics

Test Subject	Experience	Years
Test Subject A	Firefighter (Captain)	21
	Emergency Medical Technician (EMT)	21
	Search and Rescue	21
	Hazardous Materials (HAZMAT) Technician	14
Test Subject B	Firefighter	25
	EMT	25
	Search and Rescue	25
	HAZMAT Technician	20
Test Subject C	Firefighter	14
	EMT	20
	Search and Rescue	15
	HAZMAT Technician	13
Test Subject D	Firefighter	22
	EMT	18
	Search and Rescue	22
	HAZMAT Technician	5
	Law Enforcement	9

3.4 Testing Mechanisms and Criteria

The operational field assessment of the Fit-Ear earpieces used two types of testing mechanisms, specification and observable assessments, which are described in the following paragraphs.

Specification. The specification assessment included the verification of items identified as fact and did not involve the actual operation of the equipment. These items were provided by the manufacturer, such as the initial cost of the item, warranty information, and available accessories.

Observable. The observable assessment included the actual operation of the earpieces to determine if requirements were met and to establish user feedback on the functionality and usability of the device.

The test subjects focused on specific criteria to test and evaluate the Fit-Ear MPD and VS-1 earpieces, as shown in table 3-5. The criteria are based on the recommendations of firefighters interviewed prior to the assessment.

Table 3-5. Assessment Criteria

Criteria	Specification	Observable
Capability		
Heat resistance	√	
Chemical resistance	√	
Water/moisture resistance	√	√
Wear resistance	√	√
Radio connection	√	√
Reduction of background noise	√	√
Clarity of communication		√
Affordability		
Initial cost	√	
Replacement and repair cost	√	
Warranty	√	
Maintainability		
Maintenance requirements	√	√
Special tools		√
Usability		
Personal comfort of earpiece		√
Usability with personal protective equipment (PPE)		√

3.5 Field Assessment Location and Equipment

The field assessment was performed at a firefighting training facility located at APG in Aberdeen, Maryland. The location provided a safe and secure environment for the assessment including a burn building used for live and simulated situational training (figure 3-2).

Figure 3-2. Burn Building at APG, Aberdeen, Maryland

Discussions with firefighters prior to the assessment led to the decision that a real fire in the burn building would not provide additional benefit to the results of the field assessment. Performing the assessment without using real fire reduced the risk imposed on the test subjects and allowed them to concentrate on the test and evaluation (T&E) of the Fit-Ear earpieces.

The equipment used in the field assessment scenarios included actual firefighting tools common to most fire departments. The test subjects were trained and experienced using all the equipment at the assessment. During the assessment, the test subjects evaluated the functionality and usability of the earpieces connected to a Motorola XTS 5000 radio.

A firefighter's turnout gear is often considered to be only the outer protective clothing (i.e., boots, trousers, and jacket). In regards to the field assessment and this report, the term PPE means all the items firefighters wear for each particular situation to include the turnout gear.

3.6 Data Collection

In order to capture the observations and comments of the test subjects throughout the assessment, SAIC assigned a data collector to each of the two T&E teams. This method allowed the data collectors to continually monitor and accurately record the remarks made by the test subjects as they concentrated on the assessment. The test subjects were encouraged during the assessment to provide individual opinions as to the results of the tests. Upon completion of each phase of the assessment, the data collectors debriefed the test subjects on the performance of the earpieces and recorded the data on a worksheet. In addition to recording feedback, the data collectors ensured the assessment objectives were accomplished.

3.7 Product Familiarization

Prior to the start of the field assessment scenarios, Fit-Ear administered a product overview and provided training on the installation and use of the MPD and VS-1 earpieces to the test subjects (figure 3-3). This was especially important because firefighters personalize how they wear their radio and other equipment with their turnout gear. Although the time needed to don the earpiece was minimal, the training on wearing the earpiece and routing the cord was important to them for comfort and to prevent any of the components from catching on PPE. Additionally, the test subjects noted that the earpiece volume controls were sensitive and required them to understand

how to adjust them. The data collectors recorded all comments provided by the test subjects during the training and familiarization phase of the assessment.

Figure 3-3. Test Subject Equipment Familiarization

3.8 Scenarios

Scenarios were developed that required the test subjects to perform simulated firefighting and rescue incidents using standard firefighting equipment that produced background noises firefighters are accustomed to hearing. The test subjects wore the appropriate PPE required for each task and used standard emergency response communication.

The burn building was utilized for the simulated building fire in scenario 1; for scenario 2, a large metal tank was used to simulate a tanker truck that had rolled over. A building approximately 200 yards from the burn building was used as a command post for parts of the assessment.

The MPD and VS-1 earpieces were tested independently of each other. The test subjects tested the MPD earpiece first through both scenarios, then were debriefed on the MPD performance. The test subjects then moved on to test the VS-1 through both scenarios, followed by the VS-1 debriefing. This ensured that all test subjects concentrated on the same earpiece at the same time, thereby eliminating any confusion of the results during the debriefings.

3.8.1 Scenario 1 – Responding To a Building Fire. This scenario began with the test subjects of both teams donning PPE and the designated earpiece at the command post. The test subjects activated the fire alarm at the command post and communicated throughout the building, including close proximity to the actual alarms and the alarm control panel. Firefighters interviewed prior to the field assessment explained that they often go into buildings with the audible alarms and have difficulty communicating because of the noise. Upon completion of the alarm test, one test subject remained behind as the incident commander (IC) while the others boarded a fire truck and departed for the simulated building fire. The test subjects in the truck operated the vehicle air horn and sirens and communicated to the IC at the command post until reaching the burn building, at which time the test subject acting as the IC joined the rest of the test subjects at the burn building (figure 3-4).

Figure 3-4. Test Subjects Drive Fire Truck To Building Fire

Upon arriving at the simulated building fire, the test subjects worked together to connect a 1-1/2-inch fire hose and then charged the pump station on the truck. Team 1 entered the building as the hose team, while team 2 remained at the fire truck to assume the duties of the IC. These tasks provided an opportunity for the test subjects to communicate between the hose team and the IC with background noises of the fire truck, pump station, and the charged hose (figure 3-5).

Figure 3-5. Hose Team Enters Building

Inside the building, the hose team adjusted the nozzle position at both solid stream and fog and applied water in the doorways and rooms to simulate noise produced by water exiting the hose and contacting different building surfaces. The hose team test subjects were able to experience the comfort of the earpiece and its capability to be used with PPE while performing different maneuvers with the hose. Additionally, the test subjects began to exert themselves, thereby breathing heavier during communication. Sweat from the exertion and water spray from the hose provided an opportunity for the test subjects to test the moisture resistance of the earpiece and its ability to remain in place in the ear (figure 3-6).

Figure 3-6. Test Subjects Communicate While Using Hose

The test subjects advanced to the second floor of the building via the stairwell while carrying the hose. This task continued to exert the test subjects and further tested the capability of the earpiece to be used with PPE (figure 3-7).

Figure 3-7. Test Subjects Test Earpiece With Different Maneuvers

On the second floor, the test subjects responded to a simulated victim. The data collector accompanying the team acted as the voice of the victim. This task allowed the test subjects to communicate with the victim by relying on ambient sound of voices. The test subjects then carried the victim out of the building while communicating with the IC (figure 3-8).

Figure 3-8. Test Subjects Communicate With Victim

After the victim was removed from the building, the test subjects climbed a ladder to the roof of the second floor while carrying a chain saw to cut an access hole in the roof. These common tasks experienced by firefighters tested the earpiece usability with PPE. The test subjects communicated the entire time with the IC as they would have in real-life situations (figure 3-9).

Figure 3-9. Test Subjects Climb Ladder To Second Floor

On the roof of the second floor, the test subjects simulated cutting an access in the roof using wood pallets and a gas-powered chain saw while communicating to the IC (figure 3-10), then exited the building via external stairs.

Figure 3-10. Test Subjects Use Chain Saw To Cut Access

At ground level, the test subjects staged a gas-powered, positive pressure exhaust fan at the front entrance of the building to simulate clearing the building of smoke. With the fan operating, the test subjects communicated with each other in different rooms of the building and with the IC (figure 3-11). This task concluded scenario 1.

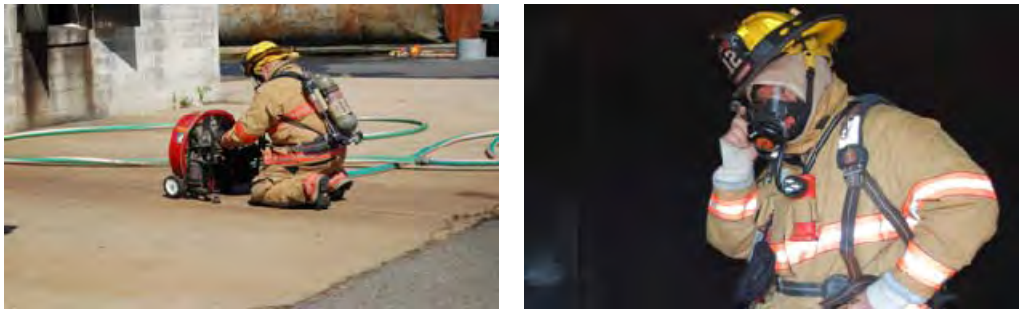

Figure 3-11. Test Subjects Communicate While Exhaust Fan Is Operating

3.8.2 Scenario 2 – Responding To a Tanker Truck Crash. This scenario began with the test subjects responding to a simulated tanker truck that had rolled on its side. As with scenario 1, team 1 advanced as the hose team while team 2 remained at the truck as the IC. The hose team adjusted the nozzle position at both solid stream and fog and applied water to the tanker as they swept from one end of the tanker to the other; this initiated different noise levels of water contacting the metal surfaces at different speeds (figure 3-12). The hose team test subjects communicated to the IC throughout the steps and were able to experience the comfort of the earpiece and its capability to be used with PPE while performing these maneuvers.

Figure 3-12. Test Subjects Extinguish Simulated Rolled Tanker Fire

After extinguishing the simulated tanker fire, the hose team used gas-powered tools to cut, snip, and spread metal in order to produce different noises that are usually experienced during victim rescue operations (figure 3-13). This task concluded scenario 2.

Figure 3-13. Test Subjects Use Gas-Powered Tools To Cut and Spread Metal

Upon completion of both scenarios, the T&E teams switched positions between the hose team and the IC and repeated all the steps of both scenarios; this provided an opportunity for all test subjects to experience each element of the assessment. The repetitiveness of the scenarios established a level of confidence in the accuracy of the assessment results. The test subjects were then debriefed before evaluating the next earpiece.

4. RESULTS OF THE FIELD ASSESSMENT

4.1 Criteria Scoring

The test subjects were asked to provide an overall score for each criteria category (see tables 4-1 and 4-2) using a scale of 1 to 5, with 1 representing performance that did not meet their expectations and a score of 5 for performance that was better than their expectations. Refer to section 4.2 for test subject observations, comments, and recommendations.

Table 4-1. MPD Earpiece Assessment Scores

Criteria Category	Test Subject A	Test Subject B	Test Subject C	Test Subject D
Capability	5.0	5.0	5.0	5.0
Usability	4.0	4.0	5.0	5.0
Maintainability	5.0	5.0	5.0	5.0
Affordability	1.0	1.0	1.0	1.0

Table 4-2. VS-1 Earpiece Assessment Scores

Criteria Category	Test Subject A	Test Subject B	Test Subject C	Test Subject D
Capability	3.0	3.0	4.0	4.0
Usability	4.0	4.0	5.0	5.0
Maintainability	5.0	5.0	5.0	5.0
Affordability	1.0	1.0	1.0	1.0

4.2 Test Subject Observations

4.2.1 Fit-Ear MPD Earpiece.

Heat resistance. Because the Fit-Ear MPD earpiece is currently commercially available, it was not a DHS requirement to test for heat resistance at the field assessment. All the test subjects stated that they felt the earpiece components would resist the level of heat they normally experience during real firefighting operations based on the specifications the manufacturer provided. The manufacturer provided the following additional data:

- The earpiece can withstand temperatures up to 900 degrees Fahrenheit.
- The earpiece cord can withstand temperatures up to 645 degrees Fahrenheit.

Note: The Electronic Safety Committee of the NFPA has been researching the performance of portable radios, thermal imaging cameras, and location devices, and how they function in extreme heat that is encountered by firefighters; however, specifics have not been published at the time of this report. NFPA 1221 states: "Mobile radios and associated equipment shall be manufactured for the environment in which they are to be used." Details of the environment are not specified. Associated equipment for radios includes microphones, earpieces, etc. A research study by the National Institute of Standards and Technology (NIST) found that radios and associated equipment that were worn under a firefighter's turnout gear were normally protected from the high temperatures and performed well.

Chemical resistance. Because the Fit-Ear MPD earpiece is currently commercially available, it was not a DHS requirement to test for chemical resistance at the field assessment. One of the test subjects remarked that he would be interested to know what the earpiece can withstand in regards to chemicals. The manufacturer was asked to provide the earpiece component specifications upon completion of the assessment.

Water/moisture resistance. The test subjects provided the following comments related to water/moisture resistance:

- One test subject stated that partially through the first scenario, he thought the earpiece was slipping out of his ear due to sweat, and when he used his hand to check it, he discovered it was still properly in place. He attributed this to "getting used" to wearing the earpiece because the earpiece is so comfortable.

- All of the test subjects agreed that the earpiece held up well to moisture from sweat and water from hose discharge (figure 4-1) and that communication performance was not affected.

Note: Fit-Ear stated that the earpiece is not waterproof but provides moderate protection from moisture because of the custom fit and internal battery and that the earpiece would not function properly if it was submerged in water for any length of time.

Figure 4-1. Test Subject Is Wet From Hose Water

Wear resistance. No issues were reported by any of the test subjects concerning resistance to damage or wear during the assessment. All test subjects felt the MPD earpiece materials were made of durable components.

Radio connection. All the test subjects were satisfied that the current version of the MPD earpiece could be connected to their Motorola radios using a simple adapter. The test subjects agreed that the Motorola radios they used at the assessment were one of the most common radios used by fire departments.

- One test subject preferred that the cord be retractable somewhere between the earpiece connection and the radio/adapter in order to take up slack in the cord.

Note: The manufacturer stated that an adapter can be made available to connect the earpiece to any type of radio.

Reduction of background noise. The test subjects overwhelmingly agreed that the performance of the MPD earpiece to reduce background noise was exceptional. In addition, the test subjects provided the following comments:

- "Background noise was not a factor throughout the assessment. I was able to hear all transmissions loud and clear both on the hose team and as IC."
- "I was amazed at the reduction of background noise and my ability to communicate clearly over any level of noise during the scenarios."
- "The combination of reducing background noise and amplifying communication transmissions makes this a great tool for firefighters."
- "Fire alarms will overpower a standard radio transmission, but communication using the MPD with the audible alarm is easily heard and understood."

Clarity of communication. As with the reduction of background noise, the test subjects overwhelmingly agreed that the ability of the MPD earpiece to provide clear, amplified communication was beyond expectations. In addition, the test subjects provided the following comments:

- "Communication with the earpiece was as if the IC was standing right next to me."
- "Communication with the earpiece was night and day better than using the radio without the earpiece."
- "Communication was 100 times better than just using the radios."
- "Communication was clear and background noise limited during all phases of the scenarios."
- "Communication was the clearest I have ever experienced as a firefighter."
- "Communication with the victim (ambient sound of voices) was easily heard and understood, which is critical in search and rescue operations."
- "Communicating with firefighters that are not in the line of sight is critical. The clarity of the MPD earpiece greatly increases the safety of the firefighter."
- "During a transmission as the IC, I could still hear ambient conversations several feet away, and that is a plus."

Personal comfort of the earpiece. The test subjects agreed that the MPD earpiece was very comfortable, and they oftentimes forgot they had them in their ears. They also provided the following comments:

- "The earpiece is very comfortable to wear. After wearing it a short time, I did not realize the earpiece was in my ear."
- "The earpiece is comfortable to the point that I would not have to remove it during a lengthy response event."
- Several test subjects did note that the earpiece cord would not stay tucked behind their ears while performing firefighting tasks and that this slightly annoyed them. One test subject recommended a rigid cord for the ear. In figure 4-2, the photo on the left shows the cord properly tucked behind the ear, while the photo on the right shows how the cord has slipped to the outside of the ear a short time after wearing.

Note: The manufacturer stated that a clip-like device that goes over the ear to eliminate the cord from coming off the ear is planned.

Figure 4-2. Proper and Improper Earpiece Cord Location

Usability with PPE. The test subjects provided many comments and recommendations about the earpiece performance with PPE. Although some of the comments may appear to be negative, the overall opinion of the test subjects is that they could use the earpiece successfully with the PPE. It should be noted that some of the test subjects felt that once they were more familiar with wearing the earpiece and cord, it would eliminate some of the issues they had at the assessment. The following test subject comments were recorded:

- The test subjects stated that they felt there was a perceived risk with the cord connecting the earpiece to the radio catching on furniture or other objects and equipment (figure 4-3). They recommended that the cord be a coiled design like the cords on their Motorola radios rather than a straight cord design. One test subject further added that firefighters often crawl around furniture in the dark and smoke where visibility can be zero, and any snagging or catching of the cable could disconnect their communication.

Figure 4-3. Test Subjects Preferred a Coiled Rather Than Straight Cord

- Several test subjects stated that there is a good possibility that the connection between the earpiece cord and the adapter could be pulled apart if they were to snag on PPE or other objects (figure 4-4).

Note: At the assessment, Fit-Ear taped the earpiece cord and adapter connections together to prevent them from coming apart. Fit-Ear stated that they will have a solution for this and that they brought this adapter specifically for this assessment.

Figure 4-4. Earpiece Cord and Adapter Connection

- Test subjects recommended the cord from the earpiece be of shorter length (approximately shoulder length) and the cord up from the radio a longer length.
- "The earpiece dislodged from my ear when I pulled my helmet off."
- "One time removing my face piece, the straps of the face piece pulled the earpiece out of my ear." (See figure 4-5.)

Figure 4-5. Facepiece Straps Pulled Earpiece Out

Note: A data collector noticed that the earpiece cord and radio worn by a test subject on the outside of his jacket was snagging on the pull cord handle of the gas-powered fan as he attempted to start the fan. This could be attributed to slack in the cord, how the radio and cord is worn, or the straight cord design. Responders wear their radios in different locations inside and outside their turnout gear; therefore, snagging or catching of the earpiece cord or adapter may vary due to the locations of the components.

Note: While climbing the ladder to the second floor of the burn building during scenario 1, both test subjects of a hose team experienced loss of communication before reaching the second floor. It was discovered that in both cases, the volume control adjustment wheel on the earpiece cord had been moved into the mute position by rubbing against PPE such as their jackets. Fit-Ear stated that they would look into modifying the volume control adjustment wheel to lock it into the selected position.

Maintenance requirements. The test subjects provided the following comments related to maintenance requirements:

- "Maintenance requirements are simplistic and not time-consuming."
- "The internal battery is easy to change with a nice 'flip out' feature."
- "Cleaning products and methods are common, such as bacterial wipes and moisture packs."

Special tools. A test subject provided the following comment related to special tools:

- "The manufacturer provides the necessary cleaning tool and storage case."

Initial cost. The test subjects provided the following comments related to initial cost:

- All the test subjects felt the quoted price of $1,650 for the MPD earpiece was expensive, and they probably would not be able to purchase one given their budget restrictions.

- One test subject remarked that, in his opinion, the earpiece at that price would be a "hard sell" to his procurement personnel.

- One test subject said he would not be able to outfit all his firefighters at that cost and added that maybe he could outfit a dedicated rescue team or just the commanders.

Note: Fit-Ear said this cost is attributed to the labor hours required to make the custom molded earpieces individually.

Replacement and repair cost. The test subjects were not sure how they felt about repair costs due to not knowing what the costs would be. The test subjects provided the following comments related to replacement and repair cost:

- "Average time of repair reported by Fit-Ear is acceptable."

- "All components of the earpiece can be repaired, which is a plus."

Note: Fit-Ear said that the earpiece would have to be returned to them for repair and that the costs were dependent on the type of repair. There are shipping costs involved with returning the earpiece, and the average repair time is 4 days less shipping time.

Warranty. The overall opinion of the test subjects is that the warranty coverage is sufficient.

Note: The manufacturer offers a 2-year warranty on all parts.

General observations. The test subjects recorded the following general observations about the MPD earpiece:

- Color coding (red and blue) the left and right earpieces for low visibility applications is recommended.

- Marking the amplification ON and OFF positions of the knob on the earpiece is recommended.

- Preset volume settings for different applications are recommended. The test subjects explained that individual responders require different volume levels, and different situations (e.g., stationed at the fire truck versus the hose team) require different volume levels.

Note: Fit-Ear stated that the preset volume technology already exists with other Fit-Ear products and that they can adapt that technology to the MPD earpiece.

4.2.2 Fit-Ear VS-1 Earpiece.

Heat resistance. Because the Fit-Ear VS-1 earpiece is currently commercially available, it was not a DHS requirement to test it for heat resistance at the field assessment. All the test subjects stated that they felt the earpiece components would resist the level of heat they normally

experience during real firefighting operations based on the specifications the manufacturer provided. The manufacturer provided the following additional data:

- The earpiece can withstand temperatures up to 900 degrees Fahrenheit.
- The earpiece cord can withstand temperatures up to 645 degrees Fahrenheit.

Note: The Electronic Safety Committee of the NFPA has been researching the performance of portable radios, thermal imaging cameras, and location devices, and how they function in extreme heat that is encountered by firefighters; however, specifics have not been published at the time of this report. NFPA 1221 states: "Mobile radios and associated equipment shall be manufactured for the environment in which they are to be used." Details of the environment are not specified. Associated equipment of radios includes microphones, earpieces, etc. A research study by NIST found that radios and associated equipment that were worn under a firefighter's turnout gear were normally protected from the high temperatures and performed well.

Chemical resistance. Because the Fit-Ear VS-1 earpiece is currently commercially available, it was not a DHS requirement to test it for chemical resistance at the field assessment. One of the test subjects remarked that he would be interested to know what the earpiece can withstand in regards to chemicals. The manufacturer was asked to provide the earpiece component specifications upon completion of the assessment.

Water/moisture resistance. A test subject provided the following comment related to water/moisture resistance:

- All of the test subjects agreed that the earpiece held up well to moisture from sweat and that communication was not affected throughout the assessment.

Note: The Fit-Ear representative stated that the earpiece is not waterproof but provides moderate protection from moisture because of the custom fit and internal battery and that the earpiece would not function properly if it was submerged in water for any length of time.

Wear resistance. No issues were reported by any of the test subjects concerning wear resistance during the assessment. All test subjects felt the VS-1 earpiece materials were made of durable components.

Radio connection. This is not applicable with the VS-1 earpiece.

Reduction of background noise. The test subjects found that the VS-1 earpiece reduces background noise better than other hearing protection devices such as foam inserts, and the amplified ambient sound provides some enhanced communication in face-to-face conversation. It did not, however, enhance communication from team member to team member when they were performing tasks that created loud noises such as operating power tools or discharging water from the hose in the burn building. They all agreed the VS-1 has its applications, but

given their choice, they would use the MPD earpiece. The test subjects provided the following comments related to the reduction of background noise:

- "Background noise was reduced, but communication was not improved. When I was on the nozzle with the water discharging, I could not hear the person behind me."
- "The loud noise from equipment such as the gas-powered saw was reduced, but I could not communicate."
- "Ambient wind noise sometimes made communication difficult."

Note: The Fit-Ear MPD and VS-1 were tested independently and at no time during the assessment were the earpieces described as functioning in the same capacity. The MPD amplifies radio transmissions, which was a big plus to the test subjects, while the VS-1 amplifies ambient sounds. The VS-1 is designed as hearing protection that still allows some ambient sound to be heard.

Clarity of communication. The test subjects provided the following comments related to communicating with the earpiece:

- "Hearing protection is improved over other types such as foam inserts, but communication was very difficult."
- "When transmitting through the lapel microphone while attached to the chest, the transmission was muffled. When the microphone was held high and closer to mouth, the transmission was loud and clear."
- "When using the saw, could not hear transmission."

Personal comfort of earpiece. The test subjects all agreed that the VS-1 earpiece was very comfortable; oftentimes, they forgot they had them in their ears.

Usability with PPE. The test subjects did not report any issues with using the VS-1 earpiece with their PPE.

Maintenance requirements. A test subject provided the following comment related to maintenance requirements:

- "Cleaning products and methods are common, such as bacterial wipes and moisture packs."

Special tools. A test subject provided the following comment related to special tools:

- "The manufacturer provides the necessary cleaning tool and storage case."

Initial cost. All the test subjects agreed that the VS-1 earpiece is expensive and may be beyond their budget to outfit all the firefighters in their department.

Replacement and repair cost. The test subjects were not sure how they felt about repair costs due to not knowing what that would be. A test subject provided the following comment related to replacement and repair cost:

- "Average time of repair as reported by Fit-Ear is acceptable."

Warranty. The overall opinion of the test subjects is that the warranty coverage is sufficient.

Note: The manufacturer offers a 2-year warranty on all parts.

General observations. The test subjects recorded the following general observation:

- Color coding (red and blue) the left and right earpieces for low visibility applications is recommended.

5. CONCLUSION

SAIC conducted an operational field assessment of the Fit-Ear MPD and VS-1 earpieces on October 5, 2011, at APG in Aberdeen, Maryland. Following the conclusion of the assessment, evaluation and analysis of the collected data were performed based on the cumulative opinions of the test subjects.

The results of the field assessment for the MPD indicate that it is highly efficient in providing clear communication and reducing background noises and can be effectively utilized with firefighting turnout gear. The test subjects found that the MPD provided them the best communication enhancement they have ever experienced and that the firefighting community would benefit from the technology. In addition, the test subjects believe that the increase in clear communication with less background noise raises the level of safety for the firefighter. The test subjects also provided valuable recommendations to enhance the usability of the MPD.

The results of the field assessment for the VS-1 indicate that it provides good hearing protection by reducing background noise and that the vented design, which allows amplified ambient sound to be heard, would be beneficial in certain applications. In their opinion, the VS-1 is an improvement from current hearing protection devices such as foam inserts and would be more valuable used as hearing protection where ambient communication is important.

For both the MPD and VS-1 earpieces, the test subjects provided positive comments on the comfort of the custom fit and the ease of use. Their main concern was that the high cost of the earpieces may prevent their jurisdictions from being able to outfit all the firefighters within each department.

APPENDIX A – INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

SAIC
From Science to Solutions

Science Applications International Corporation
1710 SAIC Drive | McLean, Virginia 22102 | t: 703.676.6000

DHHS FWA Number: 00001115
DoD Addendum: DoD N-A3018

CERTIFICATE OF APPROVAL: UPDATE/CHANGE/RENEWAL

INVESTIGATOR: John O'Neil Project Manager (443) 402-9161	**PROTOCOL IDENTIFIER:** 2011-01-01	**ADDRESS:** SAIC 3465A Box Hill Corporate Center Drive Abingdon, MD 21009
PROTOCOL TITLE: Fit-Ear MPD Series Ear Device Operational Field Assessment, aka, Fireman's Earplug Headset (FM2) Operational Field Assessment		
UPDATE/CHANGE: Revision to Protocol Title; Revision to Protocol Expiration Date as requested in Quarterly Progress Report dated 09-29-11; Minor Revisions made to Protocol and Consent Agreement in response to Board Member comments;		
UPDATE/CHANGE APPROVAL DATE: 09-30-2011 (retroactive to 05-01-2011)	**PROTOCOL EXPIRATION DATE:** 09-30-2012	**REVIEW CYCLE (months):** 3 months, quarterly
RISK LEVEL: Minimal	**REVIEW TYPE:** Board Review (by e-mail)	

The SAIC Institutional Review Board (IRB) has approved the renewal of this protocol in accordance with Federal Regulations at 45 CFR 46. A copy of the SAIC IRB approved informed consent form has been included with this notification. Copies of the SAIC IRB approved informed consent form must be used when documenting consent of human subjects for participation in this protocol.

This approval DOES NOT change the expiration date of this protocol. Regulations require that this protocol be renewed prior to the above expiration date. If this fails to occur, the SAIC IRB is required to close your protocol. The SAIC IRB will provide a reminder prior to the expiration date, but it is your responsibility to ensure that your request for renewal is received in sufficient time to be reviewed prior to the expiration date.

Changes to your protocol must be submitted to the SAIC IRB for review and approval prior to their implementation. This includes changes to the informed consent form, principal investigator, protocol, etc.

You are required to report any unexpected problems or serious adverse events, either physical or mental, to the SAIC IRB that occur during the course of your research. Any unexpected problems must be reported within 5 days and any serious adverse events must be reported within 24 hours.

Our Assurance with the federal government specifies that all signed consent documents be retained for at least 3 years past completion of the research activity.

Please feel free to contact me at 703-676-7175 or by e-mail at john.s.parker@saic.com or Nicholas Owens, Human Protections Administrator, at 703-676-2408 or by e-mail at nicholas.d.owens@saic.com if you have any questions about this approval or about SAIC IRB procedures.

Thank you for your concern for human subjects.

Sincerely,

ELECTRONIC SIGNATURE AUTHORIZED BY DR. PARKER

John S. Parker, M.D. Date: 09/30/2011
SAIC IRB Chair

CC: SAIC IRB
Nicholas Owens, HPA
Gary Waggoner, VP for EH&S

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APPENDIX B – ACRONYMS

ANSI	American National Standards Institute
APG	Aberdeen Proving Ground
CFR	Code of Federal Regulations
dB	decibel
dBA	decibel level for the human ear
DHHS	U.S. Department of Health and Human Services
DHS	U.S. Department of Homeland Security
GSA	General Services Administration
IC	Incident Commander
IRB	Institutional Review Board
MPD	Multi Purpose Device (Fit-Ear™ earpiece)
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
OHRP	Office for Human Research Protections
OSHA	Occupational Safety and Health Administration
PASS	Personal Alert Safety System
PPE	personal protective equipment
S&T	Science and Technology Directorate
SAIC	Science Applications International Corporation
SCBA	self-contained breathing apparatus
T&E	test and evaluation
VS	Vented Stereo (Fit-Ear™ earpiece)

APPENDIX C – RESOURCES

American Industrial Hygiene Association, <http://www.aiha.org/news-pubs/newsroom/Documents/Protect%20Yourself%20from%20Noise.pdf>

American National Standards Institute (ANSI), <http://www.ansi.org>

Code of Federal Regulations, <http://www.gpoaccess.gov/cfr/>

Fit-Ear, <http://www.fit-ear.com/>

Merriam-Webster, <http://www.merriam-webster.com>

National Fire Protection Association (NFPA), <http://www.nfpa.org/>

National Institutes of Health, <http://ohsr.od.nih.gov/guidelines/45cfr46.html>

Occupational Safety and Health Administration (OSHA), <http://www.osha.gov/>

Sper Scientific, <http://www.sperdirect.com/>

TechSolutions, <https://www.techsolutions.dhs.gov>

U.S. Department of Health and Human Services, <http://www.hhs.gov>

U.S. Fire Administration, <http://www.usfa.fema.gov/>