In-Suit Communications Equipment

Market Survey Report

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FOREWORD

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to help emergency responders improve their procurement decisions.

Located within the Science and Technology Directorate, the National Urban Security Technology Laboratory (NUSTL) manages the SAVER Program and conducts objective operational assessments of commercial equipment and systems relevant to the emergency responder community.

The SAVER Program gathers and reports information about equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

SAVER publications focus on answering two main questions: "What equipment is available?" and "How does it perform?"

SAVER knowledge products are created for the nation's first responders and made available to help them make operational and procurement decisions. NUSTL works with stakeholders to identify and prioritize project topics that address emergency responder needs, develops SAVER knowledge products, and coordinates with other organizations to leverage appropriate subject matter expertise.

NUSTL also provides expertise and analysis on a wide range of key subject areas, including chemical, radiological, nuclear, and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation and technologies. Under the SAVER Program, NUSTL developed this report with information obtained from a market survey of in-suit communications (ISC, or in-suit comms) equipment to provide emergency responders with reference information on currently available technologies. ISC equipment falls under AEL reference number 06CP-03-PRAC titled "Portable Radio Accessories."

For more information on the SAVER Program or to view additional reports on in-suit communications and other technologies, visit https://www.dhs.gov/science-and-technology/SAVER.

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EXECUTIVE SUMMARY

Communications are an essential lifeline in emergency response disciplines. Typically, responders use radios that continuously receive incoming communications and require the user to press a button to send outgoing messages. Such push-to-talk (PTT) tactical radios may be difficult for some emergency response disciplines such as firefighting and hazardous materials (HazMat) response. Heavy personal protective equipment (PPE) including standard turnout gear, enclosed chemical-resistant suits, gloves, and respiratory protection that is necessary to this work also presents challenges to using PTT radios. Responders outfitted in heavy PPE may have limited physical access to the radio or accessories, such as a lapel microphone, and experience difficulty in operating the PTT button. Respiratory protection equipment such as a self-contained breathing apparatus (SCBA) or air-purifying respirator (APR) may muffle outgoing voice transmissions and obscure incoming transmissions.

In-suit communications (ISC) equipment allows for easier usage of PTT radios when wearing heavy PPE. An ISC system consists of a speaker, a microphone, and a push-to-talk button. Many ISC products can be powered by the radio but some require additional batteries.

ISC products included in this report fall into one of four categories: facemask-mounted systems, throat-worn systems, in-ear systems, and bone conduction systems. Facemask-mounted systems act as conventional microphones. The microphones for the other three categories receive vibrations from various parts of the head and neck and convert them into electrical signals.

NUSTL, through its System Assessment and Validation for Emergency Responders (SAVER) Program, conducted a market survey of in-suit communications equipment. Information was gathered from a SAVER focus group held in March 2019, an operational assessment completed in August 2019, market research conducted in September 2019, and a "technology scouting request" submitted to the DHS S&T Technology Scouting and Transition group in February 2020. Market research was gathered from vendors, internet research, industry publications, and a government issued "request for information" (RFI) posted on the Federal Business Opportunities website. The survey identified 34 products: six facemask-mounted products ranging in price from $485 to $2,200, 11 throat-worn products ranging in price from $86 to $700, nine in-ear products ranging in price from $347 to $900, and eight bone conduction products ranging in price from $377 to $1,099. Performance of many of these products has not been independently verified by NUSTL.

Emergency response agencies that consider purchasing in-suit communications equipment should carefully research the overall capabilities and limitations and technical specifications of each system in relation to their agency's operational needs.

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1.0 INTRODUCTION

In-suit communications (ISC) equipment is a category of devices that allow for easier use of push-to-talk (PTT) tactical radios for responders under fully encapsulated personal protective equipment (PPE). ISC can be used with a self-contained breathing apparatus (SCBA), air purifying respirator (APR), or powered APR.

This market survey report is based on information gathered from several sources. A SAVER focus group on in-suit communications equipment met in March 2019 and a SAVER assessment took place in August 2019. Additional market research was conducted in September 2019 and in February 2020. NUSTL gathered information from vendors, internet research, industry publications, a government issued "request for information" that was posted on the Federal Business Opportunities website in September 2019, and a "technology scouting request" submitted to DHS S&T's Technology Scouting and Transition Branch in February 2020.

For inclusion in this report, the ISC product had to meet the following criteria:

- **Compatibility with fully encapsulated PPE.** The ISC equipment must be able to fit inside fully encapsulated PPE and not interfere with self-contained breathing apparatus (SCBA) masks.
- **Universal fit.** Products must not require an earpiece that must be molded specifically to the user.

Products with boom-style microphones were excluded from this market survey report by the compatibility criterion. Due diligence was performed to develop a report that is representative of products in the marketplace.

2.0 IN-SUIT COMMUNICATIONS EQUIPMENT OVERVIEW

Communications are an essential lifeline in emergency response operations. For emergency response disciplines, including firefighting and hazardous materials (HazMat) response, there are several challenges to using push-to-talk (PTT) radios while wearing heavy personal protective equipment (PPE). When a radio and accessories, such as a lapel microphone, must be worn under PPE, such as standard turnout gear or a chemical-resistant suit, physical access to the radio is limited. It can also be difficult to operate a PTT button on a radio or lapel microphone worn under PPE, especially while also wearing gloves. Additionally, respiratory protection equipment--such as a self-contained breathing apparatus (SCBA), air-purifying respirator (APR), or powered air-purifying respirator—may obscure the wearer's voice, producing muffled voice transmissions. An SCBA or APR may also make it difficult to clearly hear incoming voice transmissions. In-suit communications equipment allows firefighters and HazMat technicians to overcome these difficulties.

2.1 CURRENT TECHNOLOGIES

In-suit communications systems consist of a microphone and speaker assembly and a PTT button, which is mounted on the body. Microphones are mounted on various parts of the head, neck, or facemask. The speaker in the assembly may be a separate earpiece or integrated with the microphone.

In-ear ISC products, for example, have an earpiece which also serves as the microphone. The microphone of the ISC system is usually activated by an in-line PTT button which connects directly to the radio. For many ISC systems, the power and the volume of incoming transmissions is controlled by the radio. Some products, however, may have an integrated volume control or may require additional batteries.

ISC systems can be constructed of a single piece or can be modular in design. A modular ISC system allows for agencies to select the most appropriate earpiece, microphone, and/or PTT button for their missions. Some modular systems incorporate quick release connectors designed to mitigate the risk of a cable getting caught on any obstacles, an additional safety benefit. Although many ISC systems use an in-line PTT button, which connects directly to the radio, some systems use a control unit that serves as a central hub between the headset, the PTT button, and the radio. The control unit may simply serve as a hub for modular systems but may also have an integrated PTT button, volume control mechanism, or power source.

While most ISC systems are operated with a PTT button, some have voice activation (VOX), full duplex, or team-centered full duplex capabilities. VOX capability allows the wearer to activate the microphone simply by speaking, rather than having to press a button. This enables fully hands-free communications. "Full duplex" refers to a communication technology in which data is simultaneously transmitted and received. In the case of a half-duplex radio, the user is unable to receive transmissions when the PTT button is depressed. A full duplex system, on the other hand, does not require the use of a PTT button. A "team-centered full duplex" capability allows for full duplex communications within a talk group but requires a PTT button for communications outside of the talk group. Some ISC manufacturers refer to a team-centered full duplex capability as a "team talk" feature.

Many ISC vendors allow for custom cable lengths or coiled extendable cables to accommodate the agency's needs. Coiled cables can extend in length, allowing for greater flexibility in sizing. A coiled-cable design also reduces the length of loose cabling that might get caught on other equipment the user is wearing. Some ISC systems connect wirelessly to the radio over Bluetooth. A Bluetooth capability allows for greater flexibility in sizing, enhances the mobility of the wearer, and provides a safety benefit in its lack of cables. Some agencies may still desire a wired connection, however, because of the decreased possibility of a dropped connection between the headset and the radio.

The ISC products in this market survey report are placed into four categories: facemask-mounted systems, throat-worn systems, in-ear systems, and bone conduction systems.

Facemask-mounted systems are attached to the facepiece of an SCBA, APR, or powered APR, and operate as a conventional microphone. Some facemask-mounted systems include an external speaker (rather than over radio) for easier face-to-face communications. Facemask-mounted ISC products are often designed for use with a specific facemask but some may include universal adapters.

Throat-worn systems receive vibrations from the throat when the user speaks and convert those into electrical signals. These ISC systems are often comprised of an adjustable neckband with one or two integrated transducers.

These transducers are often designed with high sensitivity to vibrations, so they usually require very precise placement on the throat to operate properly. Systems with neckbands that fully encircle the throat often include a quick release mechanism as an added safety feature. Most throat-worn ISC products also include a separate earpiece.

In-ear systems are worn in the ear and convert vibrations in the ear canal when the user speaks into electrical signals. Some in-ear systems may have separate earpieces for speaking and listening. (For example, the right ear may serve as a microphone, while the left ear may serve as a speaker.) In-ear systems may also offer hearing protection from outside noises. Many manufacturers of in-ear ISC products offer interchangeable, universal size earpieces as well as custom earpieces molded to the wearer.

Bone conductions systems are placed at the top of the skull. Transducers receive vibrations from the skull when the user speaks and convert them into electrical signals. Many bone conduction systems must be mounted within a helmet. While most bone conduction ISC products are compatible with most helmets worn by emergency responders, manufacturers sometimes provide adapters should they be necessary. Like throat-worn ISC products, bone conduction products often have a speaker placed near the ear.

2.2 APPLICATIONS

As previously mentioned, ISC equipment allows easier radio communications for emergency responders, specifically firefighters and HazMat technicians who wear heavy PPE. In general, facemask-mounted products and bone conduction products are best suited to firefighting and HazMat response incidents. They are designed specifically for use with the PPE required for those operations. Facemask-mounted products are often designed for use with an SCBA or APR, while bone conduction systems are usually mounted within a helmet.

ISC equipment should be intrinsically safe if being used for firefighting and HazMat operations. Ingress protection (IP) ratings may also be accounted for when using ISC equipment for these two purposes. If an ISC product will be used with full Level A HazMat PPE, then a product with a lower IP rating can be used, because the chemical resistant suit provides additional ingress protection. If the product will be used with a lower level HazMat PPE or standard turnout gear, then a product with a higher IP rating should be used. More information on intrinsic safety and ingress protection is provided in Section 2.3.

Low-profile ISC systems, such as throat-worn and in-ear systems, can also be used to support communications during tactical law enforcement and military operations. Many throat-worn and in-ear systems are designed to prevent inhibiting the wearer's range of motion for these applications.

Some in-ear systems that offer hearing protection can also be used in noisy industrial environments that may be unsafe, such as factory floors or construction sites. Bone conduction products are also well suited to industrial applications since they are easily mounted within standard construction helmets.

2.3 STANDARDS & REGULATIONS

Several standards are applicable to in-suit communications equipment. Some examples of these standards are described in this section and are listed in Table 2-1.

Table 2-1 Standards Applicable to In-Suit Communications Equipment

Standard Organization & Number	Standard Title
IEC 60079 Series	Explosives Atmosphere Standards
IEC 60529	Degrees of Protection Provided by Enclosures
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
NFPA 1802 (proposed)	Two-Way Portable RF Voice Communications Devices for Use by Emergency Services Personnel in the Hazard Zone
UL 913	Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations

Although still being developed, the National Fire Protection Association (NFPA) 1802 Standard on Two-Way Portable RF Voice Communications Devices for Use by Emergency Services Personnel in the Hazard Zone is the most relevant standard to the ISC products included in this report.

The standard is currently under development by a committee comprised of firefighters, enforcing authorities, labor, applied research and testing laboratories, manufacturers, experts, and consumers.[1] The standard will identify operating environmental parameters and minimum requirements for the design, performance, testing, and certification of portable RF devices and remote speaker microphones that do not compromise field emergency services communications networks[2] and are intended for use by emergency personnel. This proposed standard also references a permission of certification of individual or combination RF devices and remote speaker microphones.

Many ISC products have an IP rating as per the International Electrotechnical Commission (IEC) International Standard 60529, entitled Degrees of Protection Provided by Enclosures (IP Code).[3] IP ratings specify a product's level of solid particle and liquid ingress protection. Products with an IP rating are provided a two-digit code. The first digit indicates the level of solid ingress protection and ranges from zero to six.

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[1] "NFPA 1802: Improving Standards for Firefighter Radios." Fire Engineering. 2018. <https://www.fireengineering.com/2018/09/17/201535/nfpa-1802-improving-standards-for-firefighter-radios/>.
[2] "NFPA 1802, Standard on Two-Way, Portable RF Voice Communications Devices for Use by Emergency Services Personnel in the Hazard Zone, proposed Edition." NFPA. 2019. <https://www.nfpa.org/assets/files/AboutTheCodes/1802/1802_F2020_FDR.pdf>.
[3] IEC60529:1989. IECEE. 2008. <https://www.iecee.org/dyn/www/f?p=106:49:0::::FSP_STD_ID:2447>.

The products in this Market Survey Report have a solid ingress protection rating of either five or six, which indicates the products are dust protected or dust tight, respectively. The second digit indicates the level of liquid ingress protection and ranges from zero to eight. Most of the products in this Market Survey Report have a liquid ingress protection rating of seven, indicating the product can withstand immersion of up to 1 meter. More information on IP ratings and levels of solid and liquid ingress protection is provided in Appendix A.

A variety of intrinsic safety standards also apply to ISC equipment. "Intrinsic safety" is the ability of a piece of electrical equipment to be used in a potentially explosive environment. Standards regarding intrinsic safety detail the protection techniques that limit the amount of electrical and thermal energy available for ignition. Two standards which define intrinsic safety specifications requirements are the IEC 60079 series and the Underwriters Laboratories (UL) UL913 standard. The main difference between these two standards is that the IEC standard is an international standard, but UL913 is specific to the United States. The IEC 60079 standard series also includes methods for testing intrinsically safe equipment and while UL913 includes requirements for equipment that may interface with intrinsically safe equipment.

The IEC 60079 series titled "Explosive Atmosphere Standards" includes several standards that detail considerations for products used in potentially explosive atmosphere. Part 25 (IEC 60079-25:2010), "Intrinsically Safe Electrical Equipment," provides design, construction, and assessment requirements for electrical systems to be used in Group I, II, or III hazardous environments.[4] According to the IEC, a Group I environment is one with the presence of methane gas. A Group II environment is one with the presences of propane gas, ethylene gas, hydrogen gas, or a combination of acetylene and hydrogen gas. Unlike Group I and II environments, a Group III environment is one with a presence of dusts, rather than gases.

These dusts may include ignitable fibers and flyings (e.g., cotton lint, flax, rayon), non-conductive dusts (e.g., flour, grain, wood, and plastic), and conductive dusts (e.g., magnesium). Part 11 (IEC 60079-11:2011), titled "Equipment Protection by Intrinsic Safety," "i" specifies the construction and testing of intrinsically equipment which connects to intrinsically safe electrical circuits.[5] The standard advises that electrical equipment to be used in an explosive atmosphere should be evaluated as per the guidelines in the standard. Part 11 also specifies that intrinsically safe equipment must meet the requirements set forth in Part 25.

The UL 913 standard, titled "Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations," details design requirements for intrinsically safe equipment to be used or installed in hazardous environments.[6] The standard also details requirements for other equipment that is used outside a hazardous environment but may interface with equipment used in a hazardous environment.

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[4] "IEC 60079-25:2010 Explosive atmospheres – Part 25: Intrinsically safe electrical systems." IEC. 2020. <https://webstore.iec.ch/publication/637>.
[5] "IEC 60079-11:2011 Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "I"." IEC. 2020. <https://webstore.iec.ch/publication/626>.
[6] "UL913 Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations." Underwriters Laboratories. 2020. <https://standardscatalog.ul.com/standards/en/standard_913_8>.

Class I, II, and III, Division 1 environments are defined by the National Fire Protection Agency (NFPA) National Electrical Code (NFPA 70) that covers the installation and removal of electrical equipment, signaling and communications systems, and optical fiber cables.[7] According the NFPA 70, a Class I environment is one with a presence of acetylene, hydrogen, ethylene, or propane gas. A Class II environment is one with a presence of metal dusts, such as magnesium, carbonaceous dusts (such as carbon or charcoal), or non-conductive dusts (such as flour, grain, wood, and plastic). A Class III environment is one with a presence of ignitable fibers and flyings, such as cotton lint, flax, and rayon.

ISC product specifications may also cite U.S. Military Standard MIL-STD-810, "Environmental Engineering Considerations and Laboratory Tests," which is maintained and enforced by the Department of Defense. The standard was initially published in 1962 and each subsequent version is identified by a letter added to the title. The newest version of the standard, MIL-STD-810H, was published in 2019. The MIL-STD-810H standard contains three sections: Environmental Engineering Program Guidelines, Laboratory Test Methods, and World Climatic Regions Guidance. The Laboratory Test Methods section addresses testing of equipment in more than 20 methods to ensure its ability to sustain various environmental stress factors.[8] This includes, but is not limited to, test methods and procedures related to high temperature, temperature shock, contamination by fluids, explosive atmosphere, acceleration, and vibration. Results of these methods may assist in learning the effects of stress factors and help determine if equipment being purchased will be reliable and durable for its use cases. Information on individual laboratory test methods are included in Appendix B.

2.4 FUTURE TECHNOLOGIES

ISC equipment has the potential to be integrated into other communications technologies used by firefighters and HazMat technicians. DHS S&T, in conjunction with Johns Hopkins University Applied Physics Laboratory, is developing the Digital Artificial Intelligence System Interface (DAISI), a voice recognition technology. The implementation of DAISI would allow firefighters and HazMat technicians the ability to use verbal commands to access and communicate information using smartphones and laptops. For example, a firefighter could initiate an automated reading of a situational report or a HazMat technician could activate a chemical sensor in an investigation. This would require further development of the DAISI technology, including the integration of ISC products with smartphones or other devices.[9]

3.0 FACEMASK-MOUNTED ISC PRODUCT INFORMATION

This section provides information on six facemask-mounted in-suit communications products. Products included in this section range in price from $485 to $2,200. Table 3-1 summarizes key product characteristics for comparison. Additional details about each product are provided in subsequent sections.

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[7] "NFPA 70: National Electrical Code." NFPA. 2020. <https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70>.

[8] "What is the difference between MIL-STD-810G and MIL-STD-810H?" Trenton Systems. 2020. <https://www.trentonsystems.com/blog/difference-between-mil-std-810g-mil-std-810h>.

[9] DAISI. Howard County Department of Fire & Rescue TV. 2020. <https://www.youtube.com/watch?v=q-dJRQjpSLM>.

Product information presented in this section was obtained directly from manufacturers, vendors, and their websites. Vendors are listed for a product if the manufacturer is not the vendor or if additional vendors distribute the product. One product included in this section was evaluated in the report "SAVER Assessment of In-Suit Communications Equipment" in August 2019. Information about all other products in this section has not been independently verified by the SAVER Program.

Product information in Table 3-1 is defined as follows:

MSRP, or manufacturer's suggested retail price, refers to the base price of the standard configuration of the product and does not include custom configurations, custom components (such as cables or earpiece tips), or accessories.

Radio compatibility refers to tactical radio models with which the product is compatible.

PPE compatibility refers to the facemasks or helmets with which the product may be used.

Power source refers to the type of batteries (AA, AAA, 9V), if used, or power drawn from the radio.

Volume control refers to mechanisms used to adjust the loudness of the earpiece speaker, including mechanisms integrated into the product or the volume knob on the radio.

Bluetooth refers to whether the product is capable of wirelessly connecting to the radio.

Voice activation refers to whether the product can be operated in VOX mode as opposed to PTT mode.

Voice amplifier refers to whether the product is equipped with a front-facing speaker for more effective in-person communications.

IP rating refers to the ingress protection rating of cable connectors as per the IP Code, in which the first digit refers to solid ingress protection and the second digit refers to liquid ingress protection. Details on each level of ingress protection are provided in Section 2.3.

Other features, as a category, includes full duplex options, customizable or coiled cables, alternate PTT buttons, earpiece options, and available accessories, such as harnesses or PPE adapters.

Table 3-1 Product Comparison Matrix for Facemask-Mounted ISC Products

Manufacturer Product	MSRP	Radio Compatibility	PPE Compatibility	Power Source	Volume Control	Bluetooth	Voice Activation	Voice Amplifier	IP Rating	Other Features
3M Scott Epic 3 RDI	$595	Motorola APX Harris XL series	3M Scott AV-2000 3M Scott AV-3000 Vision & Promask facemasks	3 AAA	Radio	✓		✓	IP67	
Dräger FPS-COM 5000	$747	Motorola, IWT, Gcai, Waris, Jedi, Entel, Sepura	Dräger FPS 7000 facemask	2 AA	Radio	✓	✓	✓	IP67	Coiled headset & PTT cables
Dräger FPS-COM 7000*	$2,200	Motorola, IWT, Gcai, Waris, Jedi, Entel, Sepura	Dräger FPS 7000 facemask	2 AA	Radio	✓	✓	✓	IP67	Coiled headset & PTT cables Team-centered full duplex built-in
MSA ClearCommand	$812	GE Ericsson, Kenwood, Motorola	NA		Radio				NA	
MSA Ultra Elite ComKit	$485	Motorola, Kenwood	MSA Ultra Elite & 3S facemasks	Radio	Radio			✓	IP66	
Scott Safety Sabrecom2	NA	Motorola, Tait, Icom, Kenwood, Maxon, Sepura, Vertex	NA	Radio	Radio				IP67	
Notes: ✓—system is equipped with corresponding feature NA—not available; this information was not provided by the vendor *Product was evaluated at the SAVER Assessment on In-Suit Communications Equipment in August 2019.										

3.1 3M SCOTT EPIC 3 RADIO DIRECT INTERFACE

The 3M Scott EPIC 3 Radio Direct Interface (RDI) consists of a microphone mounted to the facemask of an SCBA. The Epic 3 RDI is activated by the PTT button on the radio or any additional PTT accessories with which the radio is equipped. The microphone connects to the radio via a wireless Bluetooth connection. The Epic 3 RDI has an ingress protection rating of IP67. The product is powered by three AAA batteries. Volume is controlled by the radio. The product is compatible with Motorola APX series and Harris XL series radios and can be used with 3M Scott AV-2000, AV-3000, Vision, and Promask facepieces. The EPIC 3 RDI has integrated noise suppression that allows for clearer vocal communications. The EPIC 3 RDI also includes front- and rear-facing speakers to serve as a voice amplifier for face-to-face (rather than radio) communications. The product is also distributed by SOS Safety.

Figure 3-1 3M Scott EPIC 3 RDI mounted to SCBA facepiece
Image courtesy of SOS Safety

MSRP: $595

3.2 DRÄGER FPS-COM 5000

The Dräger FPS-COM 5000 consists of a microphone mounted to the facemask and a small disc-shaped earpiece that is attached to the microphone but hovers over the ear of the wearer. Front-facing speakers on the assembly allow for face-to-face communications. A 17-inch coiled cable connects the headset to the PTT button and can be extended up to 57 inches. A 23-inch coiled cable connects the PTT button to the radio and can be extended up to 85 inches. The FPS-COM 5000 is also capable of connecting to the radio wirelessly via a Bluetooth connection. The product has an ingress protection rating of IP67. The FPS-COM 5000 is powered by two AA batteries. Volume is controlled by the radio. The FPS-COM 5000 is compatible with various Motorola, IWT, Gcai, Waris, Jedi, Entel, and Sepura radio models. The product was designed for use with the Dräger FPS 7000 facemask. The FPS-COM 5000 is fully integrated, which means it is only usable with specific SCBAs, air tanks, and facemasks—all of which are manufactured by Dräger.

Figure 3-2 Drager FPS-COM 5000
Image courtesy of Dräger

MSRP: $747

3.3 DRÄGER FPS-COM 7000[10]

The Dräger FPS-COM 7000 consists of a microphone mounted to the facemask and a small disc-shaped earpiece that is attached to the microphone but hovers over the ear of the wearer. Front-facing speakers on the assembly allow for face-to-face communications. A 17-inch coiled cable connects the headset to the PTT button and can be extended up to 57 inches. A 23-inch coiled cable connects the PTT button to the radio and can be extended up to 85 inches. The FPS-COM 5000 is also capable of connecting to the radio wirelessly via a Bluetooth connection. The product has an ingress protection rating of IP67. The FPS-COM 7000 is powered by two AA batteries. Volume is controlled by the radio. The FPS-COM 7000 is compatible with various Motorola, IWT, Gcai, Waris, Jedi, Entel, and Sepura radio models. The product was designed for use with the Dräger FPS 7000 facemask. The FPS-COM 7000 is fully integrated, which means it is only usable with specific SCBAs, air tanks, and facemasks—all manufactured by Dräger. The FPS-COM 7000 is very similar to the 5000 model (see Section 3.2). The 7000 model, however, includes a Team Talk feature which allows for team-centered full-duplex, hands-free communication between multiple wearers. The Team Talk feature is activated and deactivated by a button on the microphone. A standard package available for purchase includes the communications facepiece, a PTT button and cable, and a 15-year warranty.

Figure 3-3 Drager FPS-COM 7000

Image courtesy of Dräger

MSRP: $2,200

3.4 MSA CLEARCOMMAND

The MSA ClearCommand Communications System consists of an earpiece and a lapel microphone that can be mounted to a facemask or to the inside of a helmet. The lapel microphone has an enlarged integrated PTT button. A separate, even larger PTT button is also available. The product is powered by two AAA batteries. Volume is controlled by the radio. The ClearCommand is compatible with a variety of GE Ericsson, Kenwood, and Motorola tactical radio models.

MSRP: $812

Figure 3-4 MSA ClearCommand Communications System mounted to a SCBA facemask

Image courtesy of MSA

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[10] The Dräger FPS-COM 7000 was evaluated at the SAVER Assessment of In-Suit Communications Equipment in August 2019. <https://www.dhs.gov/publication/suit-communication-equipment>.

3.5 MSA ULTRA ELITE COMKIT

The MSA Ultra Elite ComKit uses an electric microphone designed for mounting inside a mask; the microphone is activated by a separate PTT button included with the product. An integrated quick release mechanism connects the microphone to the PTT. Rather than an earpiece, the product uses a forward-facing loudspeaker to allow for face-to-face (as opposed to radio) communications while wearing an SCBA, APR, or powered air purifying respirator (PAPR). The microphone-loudspeaker assembly is designed to prevent audio feedback. Cable length is 18 inches between the headset and the PTT button and 18 inches between the PTT button and the radio connector. Cables 24 inches in length are also available. The product has an ingress protection rating of IP66. The product's power and its volume control are via radio. The Ultra Elite ComKit is compatible with various Motorola and Kenwood radio models through the use of adaptors. The product is also compatible with MSA Ultra Elite and 3S facemasks. Although the product is designed for firefighting operations, it could potentially be used for HazMat operations as well. The product is also distributed by Point Safety.

Figure 3-5 MSA Ultra Elite ComKit
Image courtesy of Point Safety

MSRP: $485

3.6 SCOTT SAFETY SABRECOM2

The Scott Safety Sabrecom2 includes a microphone mounted inside the facemask and a boom-style earpiece. The earpiece boom is flexible and can be adjusted to fit the wearer inside HazMat PPE. Cable length is 12.5 inches between the headset and the PTT button and 21 inches between the PTT button and the radio connector. Both cables include a coiled portion. The entire assembly can be stretched to 71 inches in length. The product has an ingress protection rating of IP67. The Sabrecom2 is powered by the radio. The radio also controls volume. The system is compatible with Scott PTT buttons. Available PTT buttons also include a radio connector for various Motorola, Tait, Icom, Kenwood, Maxon, Sepura, and Vertex radio models. Sabrecom2 is also available in an earpiece-only configuration that may be used when HazMat PPE is not necessary for an incident response. This configuration is compatible with a lapel microphone that has an enlarged integrated PTT button. The product is also distributed by Keison Products.

Figure 3-6 Scott Safety Sabrecom2
Image courtesy of Keison Products

MSRP: Pricing information is available from the vendor upon request

4.0 THROAT-WORN ISC PRODUCT INFORMATION

This section provides information on 11 throat-worn in-suit communications products. Products included in this section range in price from $86 to $700. Table 4-1 summarizes key product characteristics for comparison. Additional details about each product are provided in subsequent sections. Product information in this section was obtained directly from manufacturers, vendors, and their websites. Vendors are listed for each product if the manufacturer is not the vendor or if additional vendors distribute the product. One product in this section was evaluated in the report "SAVER Assessment of In-Suit Communications Equipment" in August 2019. Information about all other products in this section has not been independently verified by the SAVER Program.

Product information in Table 4-1 (and defined in Section 3.0) is organized using the following column headings:

- MSRP
- Radio compatibility
- Power source
- Volume control

- Bluetooth
- Voice activation
- IP rating
- Other features

Additional product information is defined as follows:

Transducers refers to whether the product is equipped with a single transducer or dual transducers.

Quick release refers to whether the neckband of a product is equipped with a mechanism to rapidly remove the neckband as a safety feature.

Table 4-1 Product Comparison Matrix for Throat-Worn ISC Products

Manufacturer Product	MSRP	Radio Compatibility	Transducers	Power Source	Volume Control	Quick Release	Bluetooth	Voice Activation	IP Rating	Other Features
CeoTronics CT-ThroatMike	$700	Motorola, Sepura, Airbus, Hytera	Dual	Radio	Radio				IP67	Team-centered full duplex available with additional radio infrastructure
CeoTronics CT-ThroatMike Comfort*	$700	Motorola, Sepura, Airbus, Hytera	Single	Radio	Radio	✓	✓	✓	IP67	Team-centered full duplex available with additional radio infrastructure
codeRED Assault-Pro Tactical Throat Mic Headset	$175	Kenwood, Motorola, Midland, Std 2.5 mm, Std 3.5mm	Dual	Radio	Radio				IP54 (headset) IP67 (PTT)	Coiled headset & PTT cables Finger-mounted PTT available
EarHugger Safety Throat Microphone	$86	Motorola, Kenwood, Vertex, Ericsson, MACOM, Harris, Tait, Icom, Std. 3.5mm	Dual	Radio	Radio				IP67 (radio connector) IP67 (radio)	Custom cable lengths available Finger-mounted PTT available Interchangeable universally-sized earpiece tips
iASUS NT3-R	$104	Motorola, Kenwood, Icom, Midland, Std. 3.5mm	Dual	Radio	Radio	✓			IP65	Finger-mounted PTT available
Impact PTM-1	$260	Motorola, Kenwood, Harris, Icom, Vertex	Dual	Radio	Radio	✓			IP67	Finger-mounted PTT button & wireless PTT button available Custom size earpiece tips available
Miner Mic Tactical Throat Microphone	$315	Bendix King DPH, GPH, & EPH series	Dual	Radio	Radio				IP56	

Manufacturer Product	MSRP	Radio Compatibility	Transducers	Power Source	Volume Control	Quick Release	Bluetooth	Voice Activation	IP Rating	Other Features
Motorola Tactical Throat Microphone	$377	Motorola APX series & Others	Dual	Radio	Radio	✓			NA	
OTTO Communications Throat Microphone	$400	EF Johnson, Kenwood, Motorola	Single	Radio	Radio	✓			NA	Finger-mounted PTT button available Tested to MIL-STD-810G
Savox TC-1/TM-1	NA	NA	Single	NA	NA	✓			IP67 (PTT button) NA (TM-1 & TC-1)	Customizable cable length between PTT and radio
Tactical Command Industries Tactical Throat Microphone System	$545	Motorola, Harris, Kenwood	Dual	Radio	Radio	✓			IP67	Coiled PTT cable Microphone-only configuration (no earpiece) available Sound-attenuation earpiece available Tested to MIL-STD-810F & MIL-STD-810G
Notes: ✓—system is equipped with corresponding feature NA—not available; this information was not provided by the vendor *Product was evaluated at the SAVER Assessment on In-Suit Communications Equipment in August 2019.										

4.1 CEOTRONICS CT-THROATMIKE

The CeoTronics CT-ThroatMike consists of a throat-worn microphone with dual transducers and a hearing aid-style earpiece that serves as a speaker. Cable length between the headset and the PTT button is 29.5 inches, including a 5-inch coiled section. Cable length between the PTT button and the radio is 21.5 inches. Cable connectors have an IP67 rating. The CT-ThroatMike is powered through the radio. The radio also controls the volume. The product is compatible with various CeoTronics PTT button models and includes a 12-pin connection adaptor required for use with most tactical radios. CeoTronics PTT buttons are compatible with Motorola, Sepura, Airbus, and Hytera radio models. Although the CT-ThroatMike does not have a built-in full duplex feature, a team-centered full duplex mode can be enabled through additional network infrastructure developed by CeoTronics.

MSRP: $700

Figure 4-1 CeoTronics CT-ThroatMike

Image courtesy of CeoTronics

4.2 CEOTRONICS CT-THROATMIKE COMFORT[11]

The CeoTronics CT-ThroatMike Comfort is composed of a microphone strap which is worn around the neck and a hearing aid-style earpiece which serves as a speaker. Unlike the standard CT-ThroatMike model (see Section 4.1), the CT-ThroatMike Comfort uses an elastic throat strap with a single transducer and a quick release buckle clasp for added safety. Cable length is 35 inches between the headset and the PTT button and 20 inches between the PTT button and the radio. Cable connectors have an IP67 rating. The CT-ThroatMike Comfort is powered through the radio. Volume is also controlled by the radio. The product is compatible with various CeoTronics PTT button models and includes a 12-pin connection adaptor required for usage with most tactical radios. CeoTronics PTT buttons are compatible with Motorola, Sepura, Airbus, and Hytera radio models. Although the CT-ThroatMike Comfort does not have a built-in full duplex feature, a team-centered full duplex mode can be enabled through additional network infrastructure developed by CeoTronics.

MSRP: $700 to $900

Figure 4-2 CeoTronics CT-ThroatMike Comfort

Image courtesy of CeoTronics

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[11] The CeoTronics CT-ThroatMike Comfort was evaluated at the SAVER Assessment of In-Suit Communications Equipment in August 2019. <https://www.dhs.gov/publication/suit-communication-equipment>.

4.3 CODE RED ASSAULT-PRO TACTICAL THROAT MIC HEADSET

The Assault-Pro Tactical Throat Mic Headset consists of a throat-worn microphone with two transducers and a clear coiled acoustic tube earpiece. The neckband of the microphone is adjustable to the size of the wearer. The microphone is activated by a large PTT button with an integrated clothing clip. Cable length between the headset and the PTT button is 28 inches with a coiled cable and 42 inches with a stretched cable. Cable length between the PTT button and the radio adaptor is 21 inches with a coiled cable and 48 inches with a stretched cable. The headset has an ingress protection rating of IP54 and the PTT button is rated at IP67. The product is powered by the radio, which also controls the volume. The product is compatible with various Kenwood, Motorola, and Midland radios through optional connector cables that connect the radio to the PTT button. Connector cables are also available for radios with a 2.5mm audio port or a 3.5 mm audio port. Although the product was designed for law enforcement and military applications, it could

Figure 4-3 Code Red Assault-Pro Tactical Throat Mic Headset

Image courtesy of Code Red Headsets

potentially be used for firefighting and HazMat operations. The system includes an extra PTT button that can be mounted to the wearer's finger or to a weapon (if the product is used in law enforcement or military operations).

MSRP: $175

4.4 EARHUGGER SAFETY THROAT MICROPHONE

The EarHugger Safety Throat Microphone consists of a dual transducer neckband and a clear coiled acoustic tube earpiece to be worn in one ear. The product uses an in-line PTT button that connects to the radio. Cable length between the headset and the PTT button is 18 inches. Cable length between the PTT button and the radio adaptor is 36 inches. Custom length cables are also available. Both the headset and PTT button have an ingress protection rating of IP67. Radio connector ingress protection ratings are made to match the radio. For example, if the radio is rated at IP67, then the connector will also be rated at IP67. The product is controlled by the radio and volume is also controlled by the radio. Different models of the product are available with connectors for various Motorola, Kenwood, Vertex, Ericsson, MACOM, Harris, Tait, and Icom radio models. A connector for radios with a 3.5mm audio input is also available. A separate finger-mounted PTT button is also available for the Throat Microphone. Although the product was designed for military and SWAT operations, it could potentially be applied to firefighting and HazMat operations.

Figure 4-4 EarHugger Safety Throat Microphone

Image courtesy of EarHugger Safety

MSRP: $86

4.5 IASUS NT3-R

The iASUS NT3-R consists of a microphone with a single transponder worn around the throat and a clear acoustic coil earpiece. The detachable neck strap is washable and incorporates a quick release magnetic clasp as a safety feature. The system can be used with a finger-mounted PTT button or a larger PTT button mounted on the body. Cable length is 13 inches between the headset and the PTT button and 30 inches between the PTT button and the radio connector. Custom cable lengths are available upon request. The product has an ingress protection rating of IP65. The product is powered by the radio; its volume is also controlled by the radio. The NT3-R can be purchased with specific adaptors for various Motorola, Kenwood, Icom, and Midland radio models. An adaptor for radios with a standard 3.5mm audio port is also available. Product pricing depends on the PTT button and radio adaptor selected for purchase.

Figure 4-5 iASUS NT3-R
Image courtesy of iASUS Concepts

MSRP: $104 to $204

4.6 IMPACT PTM-1

The Impact PTM-1 consists of a throat band with dual throat microphone transducers and a clear acoustic tube earpiece. The throat band is adjustable to the wearer's size. The Impact PTM-1 includes a large PTT button that can be mounted on the body or a smaller PTT button that can be worn on the ring finger of the wearer. The product has an ingress protection rating of IP67. The radio supplies power and controls the volume. The standard connector between the PTT button and radio is compatible with various Motorola radio models. A secondary connector allows for the use of other Impact radio adaptors compatible with various Kenwood, Harris, Icom, and Vertex radio models. Custom earpieces molded to the wearer and a wireless PTT button are also available for the Impact PTM-1. The product is also distributed by Magnum Electronics.

MSRP: $260

Figure 4-6 Impact PTM-1
Image courtesy of Impact Communications

4.7 MINER MIC TACTICAL THROAT MICROPHONE

The Miner Mic Tactical Throat Microphone consists of a microphone worn around the throat and clear coiled acoustic tube earpiece. The microphone is activated by a body-mounted PTT button. Cable length between the headset and PTT button is 27 inches. Cable length between the PTT button and the radio connector is 20 inches. The product has an ingress protection rating of IP56. The product is powered by the radio and volume is also controlled by the radio. The Tactical Throat Microphone was specifically designed for usage with Bendix King DPH, GPH, and EPH Series radios. Although developed for industrial use in mining operations, the product could potentially be used for firefighting and HazMat response applications. Manufactured by Miner Mic, the product is distributed by 49er Communications.

Figure 4-7 Miner Mic Tactical Throat Microphone

Image courtesy of 49er Communications

MSRP: $315

4.8 MOTOROLA TACTICAL THROAT MICROPHONE

The Motorola Tactical Throat Microphone is a throat-worn ISC product composed of a neck microphone with an adjustable cloth neckband and a clear coiled acoustic tube, earpiece. The throat necklace is 21 inches and made of stretchable material. The product does not have an ingress protection rating. The radio powers this and controls volume. The Tactical Throat Microphone is compatible with the following Motorola radios: APZ7000XE, APX8000, APX7000, APX6000, APX6000XE, APX4000, APX3000, SRX2200, APX2000, APX6000LI, APX5000, APX8000XE, MTP6550, MTP6750, and MTP830850FUG. It connects to radios via a cable with a quick disconnect mechanism. The product is also distributed by Two Way Direct.

Figure 4-8 Motorola Tactical Throat Microphone

Image courtesy of Two Way Direct

MSRP: $377

4.9 OTTO COMMUNICATIONS THROAT MICROPHONE

The OTTO Communications Throat Microphone consists of a throat-worn microphone and a detachable clear coiled acoustic tube ear piece. The strap for the throat microphone is adjustable in size and features a plastic quick release buckle. The microphone is activated by an in-line PTT button. An optional finger-worn PTT button is also available. Cable length is 30 inches between the microphone and the PTT button, 37 inches between the earpiece and the PTT button and 20 inches between the PTT button and the radio adaptor. The product does not have a formal ingress protection rating but has been tested to MIL-STD-810G. The product is powered by the radio and its volume is controlled by the radio. The OTTO Communications Throat Microphone is compatible with various EF Johnson, Kenwood, and Motorola radio models through the usage of adapters also manufactured by OTTO Communications.

Figure 4-9 OTTO Communications Throat Microphone

Image courtesy of OTTO Communications

MSRP: $400

4.10 SAVOX TM-1/TC-1

The Savox TM-1/TC-1 is a throat-microphone ISC product and consists of a flexible, washable fabric neckband with a microphone, and a D-shaped earpiece speaker. A coiled polyurethane (PUR) cable connects the headset assembly to the PTT button. This cable is ~0.16 inches in diameters and 15 inches long. This cable is connected to the earpiece and the microphone separately via a wire splitter. The earpiece is connected to the wire splitter via a 11.5 inches long polyvinyl chloride (PVC) cable ~0.1 inches in diameter. The microphone is connected to the wire splitter via an 8 inches PUR cable ~0.1 inches in diameter. Cable length between the PTT button and the radio is customizable. The TC-1 is ATEX (Atmospheres Explosible)

Figure 4-10 Savox TM-1/TC-1

Image courtesy of Savox

certified in the European Union (EU) while the TM-1 is not ATEX certified. An ATEX certification indicates that the product is intrinsically safe and can be used in potentially explosive environments. Savox PTT buttons are rated at IP67. The TM-1/TC-1 uses a 4-pole quick-release connector. Additionally, the product can be adapted to Savox Classic PTTs and can be worn with or without a helmet.

MSRP: Pricing information is available upon request from the vendor.

4.11 TACTICAL COMMAND INDUSTRIES (TCI) TACTICAL THROAT MICROPHONE SYSTEM (TTMK III)

The TCI TTMK III is a throat-worn ISC product which includes an adjustable elastic strap and a quick release clasp. A standard earpiece and a sound attenuation earpiece with additional hearing protection are both available for the TTMK III. Microphone-only configurations of the product are also available. Cable length between the headset and the PTT is 14 inches. A 17-inch coiled cabled connects the PTT button to the radio. Custom cable lengths up to 5 feet are also available. The ingress protection rating of the product is IP67. The product has also been tested to MIL-STD-810F and MIL-STD-810G. The product is powered by the radio and volume is also controlled by the radio. The TTMK III is compatible with various TCI PTT buttons with built-in connectors for different Motorola, Harris, and Kenwood tactical radio models. Product pricing depends on the radio connector and earpiece tips included with the purchase. Although developed by TCI, the TTMK III is primarily distributed by The Safariland Group.

Figure 4-11 TCI TTMK III

Image courtesy of Safariland

MSRP: $545 to $650

5.0 IN-EAR ISC PRODUCT INFORMATION

This section provides information on nine in-ear in-suit communications products. Products included in this section range in price from $348 to $900. Table 5-1 summarizes key product characteristics for comparison. Additional details about each product are provided in subsequent sections. Product information presented in this section was obtained directly from manufacturers, vendors and their websites. Vendors are listed for each product if the manufacturer is not the vendor or if additional vendors distribute the product. Three products in this section were evaluated in the report "SAVER Assessment of In-Suit Communications Equipment" in August 2019. Information about all other products in this section has not been independently verified by the SAVER Program.

Product information in Table 5-1 (and defined in Section 3.0) includes the following column headings:

- MSRP
- Radio compatibility
- Power source
- Volume control

- Bluetooth
- Voice activation
- IP rating
- Other features

Transducers refers to whether the product is equipped with a single transducer or dual transducers. (This is consistent with the definition used in Section 4.0.)

Hearing protection refers to whether the product offers additional auditory protection from loud environmental noise.

Custom earpiece refers to the availability of earpieces molded specifically to the user's ear.

Table 5-1 Product Comparison Matrix for In-Ear ISC Products

Manufacturer Product	MSRP	Radio Compatibility	Transducers	Power Source	Volume Control	Bluetooth	Voice Activation	Hearing Protection	Custom Earpiece	IP Rating	Other Features
APPI Technology Double Earpiece Micro/Speaker	$348	APPI Communications Full Duplex series	Single	Radio	Radio					IP65	Radio operates in full duplex as opposed to PTT mode Interchangeable universally-sized earpiece tips
CavCom Talk Through Your Ear*	$870	Radios with two-pin audio ports (2.5mm & 3.5mm)	Dual	9-volt	Radio		✓	✓	✓	NA	Interchangeable universally-sized earpiece tips Universal radio harness for use with HazMat PPE
CeoTronics CT-ClipCom EarMike*	$900	Motorola, Sepura, Airbus, Hytera	Single	Radio	Radio	✓	✓		✓	IP67	Team-centered full duplex available with additional radio infrastructure Interchangeable universally-sized earpiece tips
INVISIO M3s Headset	NA	Over 500 cables for first responder & military radio compatibility	Single	Radio one AA if configured with control unit	Radio					IP68	Coiled cable available for headset Cable length varies with PTT button used Available in black & desert tan colors
INVISIO X5 Headset	NA	Over 500 cables for first responder & military radios compatibility	Dual	Radio one AA if configured with control unit	Radio					IP68	Cable length varies with PTT used
QDC Clear Ear	$495	All two-way radios	Single	Radio	Radio					IP54	Coiled PTT cable Wireless connection between PTT button & control unit

Manufacturer Product	MSRP	Radio Compatibility	Transducers	Power Source	Volume Control	Bluetooth	Voice Activation	Hearing Protection	Custom Earpiece	IP Rating	Other Features
Silynx Clarus FX2	$477	Motorola, Harris, Jaguar, Kenwood, Vertex, Yaesu	Dual	Radio one AAA battery if used with smartphone	Two buttons on control unit			✓		IP67	Compatible with smartphones Utility pouch available
Silynx Clarus XPR	$595	Motorola, EF Johnson, Sepura, Icom, Harris, Jaguar, Kenwood, Yaesu	Dual	Radio one AAA battery if used with smartphone	Two buttons on control unit			✓		IP67 (headset & radio adaptor) IP68 (control unit & maritime radio adaptor)	Modular configurations available Compatible with smartphones Utility pouch available
TEA Headsets IC Pro*	$460	Motorola, Kenwood, Icom, Midland, Yaesu	Single	Radio	Radio					IP67	Coiled headset & PTT cables Interchangeable universally-sized foam earpiece tips Custom cable lengths available Tested to MIL-STD-810G

Notes:
✓—system is equipped with corresponding feature
NA—not available; this information was not provided by the vendor
*Product was evaluated at the SAVER Assessment on In-Suit Communications Equipment in August 2019.

5.1 APPI TECHNOLOGY DOUBLE EARPIECE MICRO/SPEAKER

The APPI Technology Double Earpiece Micro/Speaker, Model DBH02, is an in-ear ISC product. The product features a speaker on one side and a microphone on the other. It is optimized for a small footprint and high discretion. The product is equipped with a removable Y-shaped cable. The cable between the earbuds and the retainer has a diameter of ~0.07 inches and length of 12 inches. The cable between the retainer and the connector has a diameter of ~0.09 inches and a length of 39 inches. A wide range of ear tips are available to ensure proper fit. The headset has an ingress protection rating of IP65. The Double Earpiece Micro/Speaker is activated by full duplex and is powered through the radio. Volume is also controlled by the radio. The Double Earpiece Micro/Speaker is compatible with APPI Communications Full Duplex Radios. The product is also distributed by ITL Solutions.

Figure 5-1 APPI Technology Double Earpiece Micro/Speaker

Image courtesy of ITL Solutions

MSRP: $348

5.2 CAVCOM TALK THROUGH YOUR EARS[12]

The CavCom Talk Through Your Ears (TTYE) is an in-ear ISC product. The product is designed for use with respirators, such as an SCBA or an APR, and for use in high noise environments, such as industrial settings. The TTYE can be used with an earpiece specifically molded to the user or a universal foam ear tip. The product also offers additional hearing protection. A control unit serves as a central hub, connecting the TTYE earpieces, the PTT button (developed by Otto Communications), and the radio with a radio-specific adapter cable. Cable length is 30 inches between the earpieces and the control unit, 20 inches between the radio adaptor and the control unit, and 22 inches between the PTT button and the control unit. Custom cable lengths are also available. The product does not have an IP rating. The TTYE is powered by a 9-volt battery in the control unit. Volume adjustments are made via the radio controls. The TTYE system is compatible with radios with a 2-pin (3.5 mm and 2.5 mm) audio port. Although PTT is the main talk activation mechanism, the product also includes a voice activation (VOX) option. A universal, radio chest harness is available for operations that require Level A HazMat PPE. Product pricing depends on the radio-specific adapters, earpieces, and accessories included with the purchase.

Figure 5-2 CavCom Talk Through Your Ears

Image courtesy of CavCom

MSRP: $870 to $1,565

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[12] The CavCom Talk Through Your Ears was evaluated at the SAVER Assessment of In-Suit Communications Equipment in August 2019. <https://www.dhs.gov/publication/suit-communication-equipment>.

5.3 CEOTRONICS CT-CLIPCOM EARMIKE[13]

The CeoTronics CT-ClipCom EarMike is an in-ear ISC product. The product uses a plastic earpiece worn in one ear only. Multiple standard size earpieces are available. Custom earpieces molded to a specific user are also available. Cable length is 33 inches between the headset and the PTT button and 20 inches between the PTT button and the radio. The product has an ingress protection rating of IP67. The CT-ClipCom EarMike is powered through the radio. Volume is also controlled by the radio. The product is compatible with various CeoTronics PTT button models and includes a 12-pin connection adaptor required for use with most tactical radios. CeoTronics PTT buttons are compatible with Motorola, Sepura, Airbus, and Hytera radio

Figure 5-3 CeoTronics CT-ClipCom EarMike

Image courtesy of CeoTronics

models. Although the product does not have a built-in full duplex feature, a team-centered full duplex mode can be enabled through additional network infrastructure developed by CeoTronics.

MSRP: $900 for units with a standard earpiece; $1,200 for units with a custom earpiece

5.4 INVISIO M3S

The INVISIO M3s is an in-ear bone conduction microphone ISC product. The product has a built-in speaker and in-ear microphone for wearing in one ear, to allow for environmental awareness. Both left and right earpieces are available. The product is operated via a separate PTT button or control unit. Various PTT and control unit models developed by INVISIO are available. Cable lengths are 36 inches (straight cable) and 47 inches (coiled cable) between the headset and the PTT button. The coiled cable has a ~0.79 inches coil that extends to 9 inches. INVISIO has over 500 cables for both first responder and military radios; cable compatibility can be verified by the vendor. The product has an ingress protection rating of IP68. The product draws power through the radio if it is configured with an in-line PTT button or most Invisio control units. The Invisio V50 and X50

Figure 5-4 INVISIO M3s

Image courtesy of INVISIO

control units are powered either by the radio or one AA battery. The S10 control unit is also powered by one AA battery. Volume is controlled by the radio. The M3s is available in both black and desert tan. The product is also distributed by Marlborough Communications.

MSRP: Pricing information is available upon request from the vendor.

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[13] The CeoTronics CT-ClipCom EarMike was evaluated at the SAVER Assessment of In-Suit Communications Equipment in August 2019. <https://www.dhs.gov/publication/suit-communication-equipment>.

5.5 INVISIO X5 HEADSET

The INVISIO X5 is an in-ear microphone ISC product. The product is a dual sided headset with external microphone. The product is operated via a separate PTT button or control unit; various PTT and control unit models developed by INVISIO are available. The X5 Headset uses a quick disconnect push-pull connector with the PTT button or control unit. The X5 has a cable length of 47 inches. INVISIO has over 500 cables for both first responder and military radios; cable compatibility can be verified by the vendor. The product has an ingress protection rating of IP68. The product draws power through the radio if it is configured with an in-line PTT button or most INVISIO control units. The INVISIO V50 and X50 control units are powered either by the radio or one AA battery. The S10 control unit is also powered by one AA battery. Volume is controlled by the radio. The product is also distributed by Talking Headsets.

Figure 5-5 INVISIO X5 Headset

Image courtesy of INVISIO

MSRP: Pricing information is available upon request from the vendor.

5.6 QDC CLEAREAR

The QDC ClearEar is an in-ear product consisting of an earpiece, a control box, and a wireless PTT button. The product uses ear canal pickup technology to transmit sound via the ear canal and achieve noise reduction. The product is equipped with a cord from the earpiece to the control box, which has a diameter of ~0.07 inches and length of 43 inches, and a coiled cord from the control box to the radio, which has a diameter of ~0.17 inches and a length of 12-16 inches. The headset has an ingress protection rating of IP54. The ClearEar is powered through the radio. Its volume is also controlled by the radio. The ClearEar is compatible with all two-way radios.

MSRP: $495

5.7 SILYNX CLARUS FX2

The Silynx Clarus FX2 is an in-ear ISC product made up of a dual earpiece in-ear microphone-speaker assembly and a control unit. The product uses earbud-style earpieces and foam earpiece tips. The earpiece assembly is hardwired to the control unit. Two PTT buttons are integrated into the control unit. A separate large PTT button can also be connected to the control unit and mounted on the body. The Clarus FX2 can also be used with smartphones. The product provides electronic hearing protection. Cable length is 50 inches between the headset and the control unit and 26 inches from the control unit to the radio connector. Custom cable lengths are also available for bulk orders. The product has an ingress protection rating of IP67. If used with a radio, the product is powered by the radio. If the product is used with a smartphone or is used only for hearing protection, however, a single AAA battery is required to power the control unit. Volume is controlled by two buttons on the control unit.

Figure 5-6 Silynx Clarus FX2

Image courtesy of Silynx

The Clarus FX2 is compatible with various Motorola, Harris, Jaguar, Kenwood, Vertex, and Yaesu radio models. Various versions of the Clarus FX2 are available with radio-specific adapters hardwired to the control unit. A utility pouch for the system is available for purchase. Product pricing depends on the radio adapter included with the purchase. The product is manufactured and sold by Silynx, but is also sold by TEA Headsets.

MSRP: $477 to $520

5.8 SILYNX CLARUS XPR

The Silynx Clarus XPR is an in-ear ISC product made up of a dual earpiece in-ear microphone and speaker assembly and a control unit. The product uses hearing aid style earpieces and foam earpiece tips. Two PTT buttons are integrated into the control unit. A separate, larger PTT button can also be connected to the control unit and mounted on the body. The Clarus XPR can also be used with smartphones. The product provides electronic hearing protection. Unlike the Clarus FX2 (see Section 5.7), the Clarus XPR is capable of various modular configurations. Fixed and modular earpiece assemblies are available. The fixed earpiece is hardwired to the control unit while the modular earpiece is connected to the control unit via a quick release connector. The control

Figure 5-7 Silynx Clarus XPR

Image courtesy of Silynx

unit connects to the radio via a quick release connector and a specified radio adapter. Cable length is 50 inches between the headset and the control unit and 26 inches between the control unit and the radio connector. Custom cable lengths are also available for bulk orders. The headset and radio adaptor have an ingress protection rating of IP67. The control unit is rated at IP68. Adapters are available for maritime radios with an IP68 rating. If used with a radio, the product is powered by the radio. If the product is used with a smartphone or is used only for hearing protection, a single AAA battery is required to power the control unit. Volume is controlled by two buttons on the control unit. The Clarus XPR is compatible with various Motorola, EF Johnson, Sepura, Icom, Harris, Jaguar, Kenwood, and Yaesu radio models through the use of quick release adapters made by Silynx. A utility pouch for the system is available for purchase. Product pricing depends on the earpiece configuration and the radio adapter included with the purchase.

MSRP: $595 to $725

5.9 TEA HEADSETS INCIDENT COMMAND PROFESSIONAL[14]

The TEA Headsets Incident Command Professional (IC Pro) is an in-ear ISC product. The system consists of binaural earpieces which serve as both a microphone and a speaker. The product includes three pairs of foam ear tips (in different sizes), an ear hook wire guide, a clothing clip, a PTT button, and a radio adaptor. Cable length between the headset and the PTT button is 40 inches. A 1 ½ inch portion of the cable is coiled and extendable up to 10 inches. Cable length between the PTT button and the radio adapter is 18 inches. This cable is coiled and extendable up to 5 feet (60 inches). Cable length is customizable upon request. The product has an ingress protection rating of IP67 and has also been tested to MIL-STD-810G. The IC Pro is powered by the radio and volume is also controlled by the radio. The product is compatible with various Motorola, Kenwood, Icom, Midland, and Yaesu radio models.

Figure 5-8 TEA Headsets IC Pro
Image courtesy of TEA Headsets

MSRP: $460

6.0 BONE CONDUCTION ISC PRODUCT INFORMATION

This section provides information on 8 bone conduction in-suit communications products. Products included in this section range in price from $377 to $1,099. Table 6-1 provides a summary for comparing key product characteristics, and additional details about each product are provided in subsequent sections. Product information presented in this section was obtained directly from manufacturers, vendors, and their websites. Vendors are listed for each product if the manufacturer is not the vendor or if additional vendors distribute the product. One product in this section was evaluated in a SAVER Assessment of In-Suit Communications Equipment in August 2019. Information about all other products in this section has not been independently verified by the SAVER Program.

Product information in Table 6-1 (and defined in Section 3.0) includes the following column headings:

- MSRP
- Radio compatibility
- PPE compatibility
- Power source
- Volume control

- Bluetooth
- Voice activation
- IP rating
- Other features

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[14] The TEA Headsets IC Pro was evaluated at the SAVER Assessment of In-Suit Communications Equipment in August 2019. <https://www.dhs.gov/publication/suit-communication-equipment>.

Table 6-1 Product Comparison Matrix for Bone Conduction ISC Products

Manufacturer Product	MSRP	Radio Compatibility	PPE Compatibility	Power Source	Volume Control	Bluetooth	Voice Activation	IP Rating	Other Features
CeoTronics CT-ContactCom	$1,000	Motorola, Sepura, Airbus, Hytera	Standard fire & construction helmets	Radio	Radio			IP67	Team centered-full duplex available with additional radio infrastructure
CeoTronics CT-SkullMike*	$900	Motorola, Sepura, Airbus, Hytera	Standard fire & construction helmets	Radio	Radio			IP67	Team-centered full duplex available with additional radio infrastructure
Elno BCH300	NA	NA	Standard fire & construction helmets Nuclear biological chemical (NBC) masks	NA	NA			NA	Wireless PTT button available Open-ear design allows for situational awareness Waterproof at 80cm for 30 minutes
Motorola Tactical Boomless Temple Transducer	$377	Motorola (APX series, and others)	Standard fire & construction helmets	Radio	Radio			NA	
MSA Clear Command Helmet Communication System	$730	Motorola, Kenwood, Maxon, GE, Ericsson	Standard fire & construction helmets	Radio	Radio			NA	Lapel microphone available
QDC PeaceEar-MI	$1,099	All two-way radios	Standard fire & construction helmets Respiratory protection masks	Lithium ion battery	Control unit			IP67	Tested to MIL-STD-810F Wireless connection between PTT & control unit Open-ear design allows for situational awareness

Manufacturer Product	MSRP	Radio Compatibility	PPE Compatibility	Power Source	Volume Control	Bluetooth	Voice Activation	IP Rating	Other Features
Savox/ HC-1 Helmet-COM	NA	NA	Standard fire & construction helmets	NA	NA			IP56 (headset) IP67 (PTT button)	Coiled headset cables available Adapter available for compatibility with MSA Gallet helmets Customizable cable length between PTT button & radio Flame retardant headset cable Flashover-proof PTT cable
Savox/ HC-2 Helmet-COM	NA	NA	Standard fire & construction helmets Respiratory protection masks	NA	NA			IP56 (headset) IP67 (PTT button)	Coiled headset cables available Customizable cable length between PTT button & radio Flame retardant headset cable Flashover-proof PTT cable
Notes: ✓—system is equipped with corresponding feature NA—not available; this information was not provided by the vendor *Product was evaluated at the SAVER Assessment on In-Suit Communications Equipment in August 2019.									

6.1 CEOTRONICS CT-CONTACTCOM

The CeoTronics CT-ContactCom is a bone conduction ISC product which is mounted within a helmet that may be worn inside Level A HazMat PPE. Cable length is 31.5 inches between the headset and the PTT button and 20 inches between the PTT button and the radio. The product has an ingress protection rating of IP67. The CT-ContactCom is powered through the radio. Volume is also controlled by the radio. The product is compatible with various CeoTronics PTT button models and includes a 12-pin connection adaptor required for use with most tactical radios including Motorola, Sepura, Airbus, and Hytera radio models. Although the CT-ContactCom does not have a built-in full duplex feature, a team-centered full duplex mode can be enabled through additional network infrastructure developed by CeoTronics.

MSRP: $1,000

Figure 6-1 CeoTronics CT-ContactCom

Image courtesy of CeoTronics

6.2 CEOTRONICS CT-SKULLMIKE[15]

The CeoTronics CT-SkullMike is a bone conduction ISC product for mounting within a helmet that may be worn inside Level A HazMat PPE. Cable length between the headset and the PTT button is 30 inches, including a 9.5-inch coiled segment. Cable length between the PTT button and the radio is 20 inches. The product has an ingress protection rating of IP67. The CT-SkullMike is powered through the radio. Volume is also controlled by the radio. The product is compatible with various CeoTronics PTT button models and includes a 12-pin connection adaptor required for use with most tactical radios including Motorola, Sepura, Airbus, and Hytera radio models. Although the CT-SkullMike does not have a built-in full duplex feature, a team-centered full duplex mode can be enabled through additional network infrastructure developed by CeoTronics.

MSRP: $900

Figure 6-2 CeoTronics CT-SkullMike

Image courtesy of CeoTronics

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[15] The CeoTronics CT-SkullMike was evaluated at the SAVER Assessment of In-Suit Communications Equipment in August 2019. <https://www.dhs.gov/publication/suit-communication-equipment>.

6.3 ELNO BCH300

The Elno BCH300 is a bone conduction ISC product. The product consists of an open-ear, foldable headphone, a bone conduction microphone, and an adjustable neck strap. The open ear design allows for spatial awareness. The microphone can be activated by a PTT or wirelessly via a transmitter/receiver. The BCH300 is compatible with nuclear biological chemical (NBC) masks and most helmets. Additionally, the BCH300 is waterproof at 80cm for 30 minutes. Power and volume control information were not made available to the SAVER program.

Figure 6-3 Elno BCH300

Image courtesy of Elno

MSRP: Pricing information is available upon request from the vendor.

6.4 MOTOROLA TACTICAL BOOMLESS TEMPLE TRANSDUCER

The Motorola Tactical Boomless Temple Transducer is a bone conduction ISC product and features microphones mounted on the headgear. This product has a cable length of 3 feet (36 inches). The Boomless Temple Transducer does not have an ingress protection rating. The product is powered through the radio. The volume is also controlled by the radio. The Tactical Boomless Temple Transducer is compatible with the following Motorola radios: APX8000XE, MTD6550, APX8000, APX7000, APX6000XE, APX3000, SRX2200, APX2000, APX6000LI, APX5000, MTP830850FUG, APX4000, APX7000XE, MTP6750, and APX6000. It attaches to the radio using a 6-pin connector.

Figure 6-4 Motorola Tactical Boomless Temple Transducer

Image courtesy of Two Way Direct

MSRP: $377

6.5 MSA CLEAR COMMAND HELMET COMMUNICATION SYSTEM

The MSA Clear Command Helmet Communication System (HCS) is a bone conduction ISC product that is mounted to the inside of a helmet worn under Level A HazMat PPE. The product includes a boom-style speaker which is positioned over the wearer's ear. The Clear Command HCS is activated by a PTT. A lapel microphone is also available for when the product does not need to be worn under Level A HazMat PPE. The product is powered by the radio and the volume is also controlled by the radio. The Clear Command HCS is compatible with various Motorola, Kenwood, Maxon, and GE Ericsson radio models.

Figure 6-5 MSA Clear Command HCS

Image courtesy of MSA

MSRP: $730

6.6 QDC PEACEEAR-MI

The QDC PeaceEar-MI is a bone conduction ISC product that transmits audio signals with electromechanical transducers and transfers vibrational signals to the ear through facial bones. The product consists of a head-mounted microphone and a control box. Cable length from the headset to the control box is 29 inches and has a diameter of ~0.15 inches; the cable length from the control box to the connector is scalable from 2 to 3 inches. The product has an ingress protection rating of IP67 and meets MIL-STD-810F. The system is powered by a lithium Ion battery. The volume is managed via the control box. The PeaceEar-MI is compatible with all two-way radios as well as most personal protective equipment, including helmets and gas masks. This product has an open-ear design to allow for situational awareness and is operated via a wireless PTT.

MSRP: $1,099

6.7 SAVOX HC-1 HELMET-COM

The Savox HC-1 Helmet-COM is a bone conduction one-ear ISC product and can mount into most helmet types to provide hands-free communication. This product is connected to Savox PTT buttons via a 4-pole quick-release connector. A coiled flame-retardant cable connects the HC-1 Helmet-COM to the PTT button; the cable is ~0.16 inches in diameter and 15 inches in length. A straight flashover-proof cable is also available; it measures ~0.16 inches in diameter and 29.5 inches in length. The HC-1 Helmet-COM has an ingress protection rating of IP56. Savox PTT buttons are rated at IP67. A separate adaptor is available for use with MSA Gallet helmets. Power and volume control information were not made available to the SAVER program.

Figure 6-6 Savox HC-1 Helmet-COM

Image courtesy of Savox

MSRP: Pricing information is available upon request from the vendor.

6.8 SAVOX HC-2 HELMET-COM

The Savox HC-2 Helmet-COM is a bone conduction ISC product equipped with two speakers and can be mounted into full protection fire helmets. This product is connected to Savox PTT buttons via a 4-pole quick-release connector. A coiled flame-retardant cable connects the HC-2 Helmet-COM to the PTT button; the cable is ~0.16 inches in diameter and 15 inches in length. A straight flashover-proof cable is also available; it measures ~0.16 inches in diameter and 29.5 inches in length. The HC-1 Helmet-COM has an ingress protection rating of IP56. The HC-2 Helmet-COM can be used in combination with a breathing mask. Power and volume control information were not made available to the SAVER program.

Figure 6-7 Savox HC-2 Helmet-COM

Image courtesy of Savox

MSRP: Pricing information is available upon request from the vendor.

7.0 VENDOR CONTACT INFORMATION

Additional information on the in-suit communications equipment included in this market survey report can be obtained from the vendors listed in Table 7-1. Products may also be available from vendors not listed in this report.

Table 7-1 Vendor Contact Information

Vendor	Address	Phone Number	E-mail
3M Scott	4320 Goldmine Rd, Monroe, NC 28110	704-291-8300	Us-3m-ScottMonroeCSR@mmm.com
49er Communications	361 Railroad Ave, Nevada City, CA 95959	800-552-0707	sales@49er.cc
APPI Technologies	185 Alewife Brook Pkwy, Ste 210, Cambridge, MA 02138	208-243-5585	Inquiries through vendor website
CavCom	1872 Industries Ln, Walker, MN 56484	866-547-4988	Inquiries through vendor website
CeoTronics*	Adam-Opel-Str. 6, 63322 Rödermark, Germany	+49 6074 8751-0	Inquiries through vendor website
Code Red Headsets	2892 S. Santa Fe Ave, Ste 117, San Marcos, CA 92069	858-486-9859	info@coderedheadsets.com
Dräger	7256 S Sam Houston W Pkwy, Ste 100, Houston, TX 77085	800-437-2437	Inquiries through vendor website
Ear Hugger Safety	PO Box 1222, American Fork, UT 84003	888-417-2245	Inquiries through vendor website
Elno*	43 rue Michel Carré, 95100 Argenteuil, France	+33(0) 1 39 98 44 44	sales@elno.fr
iASUS Concepts*	4940 No. 3 Rd, Richmond, BC, Canada V6X 3A5	310-601-4066	Inquiries through vendor website
Impact Communications	301 N Green Meadows Dr, Unit #F, Wilmington, NC 28405	866-532-9005	Inquiries through vendor website
INVISIO Communications	150 N Michigan Ave, Ste 1950, Chicago, IL 60601	844-968-4746	usa@invisio.com
ITL Solutions	96 Mohawk Rd, Hampton, VA 23669	757-563-3485	info@itl-solutions.com
Keison Products*	32 Writtle Rd, Chelmsford, Essex CM1 3BX, United Kingdom	+44(0) 3300880560	info@keison.co.uk

Vendor	Address	Phone Number	E-mail
Magnum Electronics	927 Horsepond Rd, Dover, DE 19901	302-734-9250	Inquiries through vendor website
Marlborough Communications*	Dovenby Hall, Balcombe Rd, Horley, Surrey RH6 9UU United Kingdom	+44(0) 1293775071	Inquiries through vendor website
Motorola Solutions	500 W Monroe St, Ste 4400, Chicago, IL 60661	888-325-9336	Inquiries through vendor website
MSA	1000 Cranberry Woods Dr, Cranberry Township, PA 16066	877-672-3473	info.us@msasafety.com
Otto Communications	2 East Main St, Carpentersville, IL 60110	847-428-7171	info@ottoexcellence.com
Point Safety*	Sutton House 13A Duke St, Southport, Merseyside, PR8 1LS, United Kingdom	+44(0) 1704330315	sales@pointsafety.com
QDC*	7/ F, Nanhang Building, 7 Langshan Road, Hi-Tech Industrial Park (North), Nanshan District, Shenzhen,518057, China	+86(0) 755 86185918	sales@qdc.com
Safariland	13386 International Pkwy, Jacksonville, FL 32218	800-347-1200	customercare@safariland.com
Savox	75 South Clinton Ave, Ste 510, Rochester, NY 14604	866-987-0801	sales@savox.com
Silynx	9901 Belward Campus Dr Ste 150, Rockville MD 20850	866-325-1731	info@silynxcom.com
SOS Safety	20283 State Road 7 Ste 400, Boca Raton, FL 33498	561-237-4247	info@sos-safety.com
Talking Headsets*	Straightpoint Building, Clovelly Rd, Southbourne, Hampshire, PO10 8PE, United Kingdom	+44(0) 1243375708	info@talkingheadsets.co.uk
TEA Headsets	16 Mount Ebo Rd S, Ste 6 (PO Box 404), Brewster, NY 10509	845-278-0960	russ@TEAheadsets.com (Southern US); kurt@TEAheadsets.com (Northern US); gerard@TEAheadsets.com (West Coast)
Two Way Direct	3262 Grey Hawk Ct, Carlsbad, CA 92010	833-201-9883	Inquiries through vendor website
*International Vendor			

8.0 CONCLUSIONS

Due to the usage of heavy PPE, radio communications can be more difficult during firefighting and HazMat response operations. In-suit communications (ISC) equipment allows firefighters and HazMat technicians to more easily use their PTT radios. In-suit communications systems include a speaker that serves as an earpiece, a microphone, and a PTT button (or voice activation device).

This market survey report provides information on 34 in-suit communications products. The products described herein include:

- Six facemask-mounted systems that attach to the facepiece of an SCBA, APR, or powered APR and operate as a conventional microphone (priced from $485-$2,200)
- 11 throat-worn systems that convert vibrations from the throat into electrical signals (priced from $86-$700)
- Nine in-ear systems that convert vibrations from the ear canal into electrical signals (priced from $348-900)
- Eight bone conduction systems that convert vibrations from the skull into electrical signals and are mounted inside helmets (priced from $377-$1,099)

While many of the products in this report use an in-line PTT button connected to the radio, some ISC systems use a control unit as the central hub for the headset, PTT button, and radio connector. Many of the systems are powered by the radio, but some rely on additional batteries. Other features available in some ISC products include additional PTT button configurations, voice activation, Bluetooth capability, full duplex "team talk" mode, and front-facing speakers or voice amplifiers.

Emergency responder agencies that consider purchasing in-suit communications systems should carefully research each product's overall capabilities and limitations in relation to their agency's operational needs.

Appendix A. IP CODE INGRESS PROTECTION LEVELS

This section provides information on the levels of ingress protection as specified by the IEC 60529 standard. Table 8-1 provides levels of solid ingress protection. Table 8-2 provides levels of liquid ingress protection.[16]

Table 8-1 Levels of Solid Ingress Protection as per IP Code

Level	Object Size Protected Against	Effective Against
0	Not protected	No protection against contact and ingress of objects.
1	>50mm	Any large surface of the body, such as the back of the hand, but no protection against deliberate contact with a body part.
2	>12.5mm	Fingers or similar objects
3	>2.5mm	Tools, thick wires
4	>1mm	Most wires, screws
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; complete protection against contact.
6	Dust tight	No ingress of dust; complete protection against contact

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[16] "IP Rating Chart." DSM&T. 2020. <http://www.dsmt.com/resources/ip-rating-chart/>.

Table 8-2 Levels of Liquid Ingress Protection as per IP Code

Level	Object Size Protected Against	Effective Against
0	Not protected	
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect.
2	Dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15° from its normal position.
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.
4	Splashing water	Water splashing against the enclosure from any direction shall have no harmful effect.
5	Water jets	Water projected by a nozzle (6.3mm) against enclosure from any direction shall have no harmful effects.
6	Powerful water jets	Water project in powerful jets (12.5mm nozzle) against the enclosure from any direction shall have no harmful effects.
7	Immersion up to 1m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1m of submersion).
8	Immersion beyond 1m	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects.

Appendix B. MIL-STD-810 LABORATORY TEST METHODS

This section provides information about laboratory test methods specified by MIL-STD-810. Table 8-3 provides the title and purpose of each test method.

Table 8-3 Laboratory Test Methods as per MIL-STD-810

Method Number	Title	Purpose[17]
500	Low Pressure (Altitude)	Use low pressure (altitude) tests to determine if materiel can withstand and/or operate in a low-pressure environment and/or withstand rapid pressure changes.
501	High Temperature	Use high temperature tests to obtain data to help evaluate effects of high-temperature conditions on material safety, integrity, and performance.
502	Low Temperature	Use low temperature tests to obtain data to help evaluate effects of low temperature conditions on materiel safety, integrity, and performance during storage, operation, and manipulation.
503	Temperature Shock	Use the temperature shock test to determine if materiel can withstand sudden changes in the temperature of the surrounding atmosphere without experiencing physical damage or deterioration in performance.
504	Contamination by Fluids	Use contamination by fluids test to determine if materiel (or material samples) is affected by temporary exposure to contaminating fluids (liquids) such as may be encountered and applied during its life cycle, either occasionally, intermittently, or over extended periods.
505	Solar Radiation (Sunshine)	This method has two purposes, (1) to determine the heating effects of direct solar radiation on materiel, and (2) to help identify the actinic (photodegradation) effects of direct solar radiation.
506	Rain	Determine the following with respect to rain, water spray, or dripping water: (1) The effectiveness of protective covers, cases, and seals in preventing the penetration of water into the materiel; (2) The capability of the materiel to satisfy its performance requirements during and after exposure to water; (3) Any physical deterioration of the materiel caused by the rain; (4) The effectiveness of any water removal system; and (5) The effectiveness of protection offered to a packaged materiel.
507	Humidity	Determine the resistance of materiel to the effects of a warm, humid atmosphere.
508	Fungus	Assess the extent to which materiel will support fungal growth and how any fungal growth may affect performance or use of the materiel.
509	Salt Fog	Determine the effectiveness of protective coatings and finishes on materials. It may also be applied to determine the effects of salt deposits on the physical and electrical aspects of materiel.
510	Sand and Dust	Dust (< 150μm) procedure – evaluate the ability of materiel to resist the effects of dust that may obstruct openings, penetrate into cracks, crevices, bearings, and joints, and to evaluate the effectiveness of filters. Sand (150 to 850μm particle size) procedure – performed to help evaluate the ability of materiel to be stored and operated in blowing sand conditions without degrading performance, effectiveness, reliability, and maintainability due to abrasion (erosion) or clogging effects of large, sharp-edged particles.

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[17] "Environmental Engineering Considerations and Laboratory Tests." Department of Defense. 2008. <https://www.atec.army.mil/publications/Mil-Std-810G/Mil-Std-810G.pdf>.

Method Number	Title	Purpose[17]
511	Explosives Atmosphere	Demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition or demonstrate that an explosive or burning reaction occurring within encased materiel will be contained and will not propagate outside the test item.
512	Immersion	Determine if materiel can withstand immersion or partial immersion in water (e.g., fording), and operate as required during or following immersion.
513	Acceleration	Assure that materiel can structurally withstand the steady state inertia loads that are induced by platform acceleration, deceleration, and maneuver in the service environment, and function without degradation during and following exposure to these forces. Acceleration tests are also used to assure that materiel does not become hazardous after exposure to crash inertia loads.
514	Vibration	Performed to (1) develop materiel to function in and withstand the vibration exposures of a life cycle including synergistic effects of other environmental factors, materiel duty cycle, and maintenance. This method is limited to consideration of one mechanical degree-of-freedom at a time. Refer to Method 527 for further guidance on multiple exciter testing. Combine the guidance of this method with the guidance of Part One and other methods herein to account for environmental synergism. (2) Verify that materiel will function in and withstand the vibration exposures of a life cycle.
515	Acoustic Noise	Determine the adequacy of materiel to resist the specified acoustic environment without unacceptable degradation of its functional performance and/or structural integrity.
516	Shock	Performed to provide a degree of confidence that materiel can physically and functionally withstand the relatively infrequent, non-repetitive shocks encountered in handling, transportation, and service environments. This may include an assessment of the overall materiel system integrity for safety purposes in any one or all of the handling, transportation, and service environments; determine the materiel's fragility level, in order that packaging may be designed to protect the materiel's physical and functional integrity; and test the strength of devices that attach materiel to platforms that can crash.
517	Pyroshock	Performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by the detonation of a pyrotechnic device on a structural configuration to which the materiel is mounted; and experimentally estimate the materiel's fragility level in relation to pyroshock in order that shock mitigation procedures may be employed to protect the materiel's structural and functional integrity.
518	Acidic Atmosphere	Determine the resistance of materials and protective coatings to corrosive atmospheres, and when necessary, to determine its effect on operational capabilities.
519	Gunfire Shock	Performed to provide a degree of confidence that materiel can structurally and functionally withstand the relatively infrequent, short duration, transient, high rate repetitive shock-input encounter in operational environments during the firing of guns.
520	Temperature, Humidity, Vibration, and Altitude	Determine the combined effects of temperature, humidity, vibration, and altitude on airborne electronic and electro-mechanical materiel with regard to safety, integrity, and performance during ground and flight operations. Some portions of this test may apply to ground vehicles, as well. In such cases, references to altitude considerations do not apply.

Method Number	Title	Purpose[17]
521	Icing/Freezing Rain	Evaluate the effect of icing on the operational capability of materiel. This method also provides tests for evaluating the effectiveness of de-icing equipment and techniques, including prescribed means to be used in the field.
522	Ballistic Shock	This method includes a set of ballistic shock tests generally involving momentum exchange between two or more bodies, or momentum exchange between a liquid or gas and a solid, performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by high levels of momentum exchange on a structural configuration to which the materiel is mounted; and experimentally estimate the materiel's fragility level relative to ballistic shock in order that shock-mitigation procedures may be employed to protect the materiel's structural and functional integrity.
523	Vibro-Acoustic/Temperature	Performed to determine the synergistic effects of vibration, acoustic noise, and temperature on externally carried aircraft stores during captive carry flight. Such determination may be useful for, but not restricted to, the following purposes: (1) To reveal and correct design weaknesses (Test, Analyze, and Fix (TAAF) test); (2) To determine whether a design meets a specified reliability requirement (Reliability Demonstration test); (3) To reveal workmanship or component defects before a production unit leaves the place of assembly (Screening test); (4) To estimate the Mean Time Between Failure (MTBF) of a lot of units based upon the test item's time to failure of a small sample of the units (Lot Acceptance test); and (5) To determine the relative reliability among units based upon the test item's time to failure of a small sample of the units (Source Comparison test).
524	Freeze-Thaw	Determine the ability of materiel to withstand the effects of moisture phase changes between liquid and solid, in or on materiel, as the ambient temperature cycles through the freeze point; and the effects of moisture induced by transfer from a cold-to-warm or warm-to-cold environment.
525	Time Waveform Replication	Performed to provide a degree of confidence that the materiel can structurally and functionally withstand the measured or analytically specified test time trace(s) to which the materiel is likely to be exposed in the operational field environment; and experimentally estimate the materiel's fragility level in relation to form, level, duration, or repeated application of the test time trace(s).
526	Rail Impact	Replicate the railroad car impact conditions that occur during the life of transport of systems, subsystems, and units, hereafter called materiel, and the tiedown arrangements during the specified logistic conditions.
527	Multi-Exciter Testing	Performed to provide a degree of confidence that the materiel can structurally and functionally withstand a specified environment, e.g., stationary, non-stationary, or of a shock nature, that must be replicated on the test item in the laboratory with more than one motion degree-of-freedom consideration.
528	Mechanical Vibrations of Shipboard Materials	Specifies procedures and establishes requirements for environmental and internally excited vibration testing of naval shipboard equipment installed on ships