



Through-the-Wall Sensors for Law Enforcement:

Best Practices

Version 1.0

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Center of Excellence (CoE)

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All legal aspects regarding expectation of privacy issues, probable cause, warrants and any other operational law enforcement procedures should be researched by agencies and their officers in accordance with local, state and federal laws prior to the implementation of technology described herein.

Organizations and individuals should seek legal counsel before operating through-the-wall systems. These devices are subject to Federal Communications Commission (FCC) regulations under Title 47, Parts 15 and 90 of the Code of Federal Regulations (CFR).



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1.0 Executive Summary

The National Institute of Justice (NIJ) Sensor, Surveillance, and Biometric Technologies (SSBT) Center of Excellence (CoE) has undertaken a best practices report of through-the-wall sensor (TTWS) devices for operation by law enforcement and first responder agencies in the United States. These devices use a form of radar to detect movement behind barriers. The ability to sense the presence of individuals through common building materials can be useful during rescue operations, law enforcement operations and other tactical scenarios.

This report provides advice, tactics and information related to the use of TTWS in operational settings. The information provides law enforcement individuals and organizations with a better understanding of the capabilities and limitations of available TTWS equipment. When put into practice, an agency can make the most of the technology and improve the outcome and safety of operational scenarios in which it is deployed. The best practices report focuses on the use of commercially available TTWS devices suitable for law enforcement or emergency response applications.

A Frequently Asked Questions section is included that provides answers to common questions or concerns that criminal justice practitioners may have before purchasing, during training or while using TTWS devices. The report provides key advice that should be considered each time a TTWS is deployed, including advice and information on training, basic measurement practices and known limitations.

Note: The best practices report is a companion report to other activities both underway and completed by the SSBT CoE. A TTWS market survey, *Through-the-Wall Sensors for Law Enforcement: Market Survey*, was completed in October 2012 (<https://justnet.org/pdf/00-WallSensorReport-508.pdf>), and another report is underway, *Through-the-Wall Sensors for Law Enforcement: Test & Evaluation*, that includes detailed information on test and evaluation activities and performance results. All information is a part of the NIJ and SSBT CoE efforts to understand, evaluate and communicate the technology to the criminal justice community.



2.0 Introduction

NIJ has identified a technology for first responders to be able to sense the presence of persons through visually obscure barriers. The ability to sense the presence of individuals through common building materials can be useful during rescue operations, law enforcement operations and other tactical scenarios. Firefighters could use the ability to detect individuals to more safely clear dangerous areas (e.g., buildings that are on fire could be checked for trapped survivors), rescue personnel could use TTWS to more easily locate survivors after a building collapse and law enforcement personnel could use TTWS to enhance situational awareness during tactical operations (e.g., building clearance, hostage threat situations).

TTWS can display a variety of information, from the simple “movement detected” to a two-dimensional (2D) graphical representation of detected movement in relation to the sensor. Devices may also provide additional information, such as a graphical representation of repetitive movement (as would be expected in the detection of breathing). Some data interpretation is straightforward (such as the display of “movement detected”), and other data interpretation may require training on the instrument for optimal use. The amount of training needed depends on the amount, quality and level of data presented by the instrument.

The NIJ SSBT CoE has undertaken a best practices report of TTWS devices for operation by law enforcement and first responder agencies in the U.S. This report provides advice, tactics and information related to the use of TTWS in operational settings. The information provides law enforcement individuals and organizations with a better understanding of the capabilities and limitations of available TTWS equipment. When put into practice, an agency can make the most of the technology and improve the outcome and safety of operational scenarios in which it is deployed.

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2.1 About the SSBT CoE

The NIJ SSBT CoE is a center within the National Law Enforcement and Corrections Technology Center (NLECTC) System. The CoE provides scientific and technical support to NIJ's research and development efforts. The Center also provides technology assistance, information and support to criminal justice agencies. The CoE supports the NIJ sensor and surveillance portfolio and biometrics portfolio. The Centers of Excellence are the authoritative resource within the NLECTC System for both practitioners and developers in their technology area(s) of focus. The primary role of the CoEs is to assist in the transition of law enforcement technology from the laboratory into practice by first adopters.



3.0 Commercially Available Equipment (FCC Certified)

A summary of the commercially available Federal Communications Commission (FCC)-certified TTWS systems suitable for law enforcement or emergency response applications is provided for ease of reference and comparisons. Additional information on the various TTWS devices can be found in the companion report produced by the NIJ SSBT CoE, *Through-the-Wall Sensors for Law Enforcement: Market Survey* (<https://justnet.org/pdf/00-WallSensorReport-508.pdf>).

Key characteristics and parameters are assembled in Table 1, with explanations of the fields below.

- **Product Name** and **Manufacturer**.
- **Unit Cost** is the cost in U.S. dollars of a single unit with supporting material (if needed) for operating the device in the field.
- **Training** indicates whether training is included for the operation of the instrument.
- **Operating Range** is the manufacturer-stated range at which the device can detect a target without attenuating barriers, unless otherwise noted. "Without attenuating barriers" was chosen as the base for this parameter because signal frequencies, barrier properties and signal properties all effect range in differing dependencies.
- **Field of View** indicates the angular width at which the device is able to detect targets.
- **Weight** is the weight of the device as it would be operated.
- **Battery Life** (where applicable) is the length of operational time that the device can be operated on one set of fully charged (or fresh) batteries.
- **Frequency** is the frequency or frequency range that the device uses to form the signal used for target detection.

Table I: Commercially Available TTWS in the U.S.

Product Name	Mfg.	Unit Cost	Training	Operating Range ¹ (meters)	Field of View (degrees)	Weight (lbs)	Battery Life	Frequency (GHz)
Range-R	L3	\$6,000 ²	Included	15.25	160	1.2	400 uses	3.18 – 3.42
Xaver 100	Camero-Tech	\$9,000	Included	20 ³	120	1.2	3 hrs	3 – 10
Xaver 400	Camero-Tech	\$47,500	Included	20	120	7	2.5 - 4.5 hrs ⁴	2 – 10

¹ The effective operating range to a target through a barrier is dependent on the barrier material composition, signal composition/shape and output frequency(s).

² Range-R Link with wireless monitoring and control costs \$9,000.

³ The preproduction model described in the SSBT CoE market survey possessed a range of 8 meters.

⁴ Dependent on the number of batteries installed in the system during operation.



4.0 Best Practices and Lessons Learned

4.1 Advice #1: Practice With the Device and Learn How to Use It

All technologies and tools require some level of practice before a user can become proficient and effectively incorporate them into regular operations. This advice is even more relevant to TTWS devices because of their use of advanced radar technology miniaturized into a compact handheld form. Depending on the device, users need to familiarize themselves with certain features and functions before use. Some TTWS devices have different modes of operation and methods for presenting information. Some devices can notify the user if the field of view is blocked by metal or a stud. Some devices have narrower field of views than others, thus requiring multiple measurements along a wall to provide accurate information. The key is to get to a point where you can easily and quickly interpret the device signals, output and limitations with respect to your operational scenarios.

4.2 Advice # 2: Think of TTWS as a Tool, but Not a Substitute for Tactical Training

When used effectively, a TTWS device can improve or even augment an operator's situational awareness and knowledge; however a TTWS device should never be used as a substitute for tactical training or instincts.

4.3 Advice # 3: Take Multiple Measurements at Different Places to Establish More Reliable Situational Awareness

TTWS have limited field of views and can be blocked by certain items, such as metal; moving to various points along a wall can only help to develop a more complete picture of the interior. One should also remember that a TTWS detects all motion, including trees and animals; therefore, always be aware of the whole environment. Additionally, many TTWS devices have different types of display output. It is best to take advantage of all information provided by the various scan modes.

4.4 Advice #4: Metal Can Block Radar Signals or Confuse Results

TTWS devices have an inherent technology limitation of which all operators should be aware. Solid metal surfaces, such as aluminum siding, will block radar signals. The device will not be able to detect movement beyond these barriers. Even metal used in construction, such as rebar or “chicken” wire used on walls to hold plaster in place, may present confusing or erratic results. Operators should observe their surroundings, take multiple measurements and fall back on their tactical training when presented unreliable results.



5.0 TTWS Operation: Frequently Asked Questions

What is the purpose of Through-the-Wall Sensors (TTWS)?

TTWS devices are designed to increase situation awareness of law enforcement and first responders. TTWS devices should not be used as the only contributing factor for entry or justification for a cause of action.

Who can use TTWS?

TTWS operation is limited to law enforcement, emergency rescue or firefighting organizations. This equipment may be operated only for law enforcement applications, the providing of emergency services and necessary training operations.

What does the Federal Communications Commission (FCC) have to do with TTWS?

The FCC governs all devices that emit radio waves, and regulates which frequencies and power levels the devices are allowed to operate. Only TTWS devices that have undergone testing and received FCC certification are permitted to be used in the U.S. Note that federal agencies do not fall under FCC jurisdiction and are instead governed by the National Telecommunications and Information Administration (NTIA).

Does the FCC approve the use of TTWS?

Yes. TTWS operators or their agencies must have a license in the Public Safety Radio Pool under Title 47 Code of Federal Regulations, Part 90. TTWS operation can also be granted under an Experimental License to organizations conducting research, development or testing.

Are there any special steps necessary before a criminal justice agency can purchase a TTWS device?

No. The FCC does not regulate or control the sale of TTWS devices, but sets forth the rules under which they can be used. Only prior possession of the above-mentioned public safety radio license is required.

There is a vendor/website selling a TTWS device not mentioned in this report. Can my criminal justice agency purchase and use it?

Yes and no. Yes you can purchase it; however, only TTWS devices that have received FCC certification are permitted to be used in the U.S. The FCC does not regulate or control the

sale of TTWS devices, but sets forth the rules under which they can be used. As a result, some vendors are selling TTWS devices that have not undergone proper certification or are imported from international manufacturers. FCC certification can be verified by requesting the FCCID from the vendor and using the FCCID to search the FCC database for authorized equipment (<https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm>).

Are there other lawful considerations prior to, or during use?

Most states require a warrant before using a TTWS device on a building, unless there is an active situation where there is no expectation of privacy, such as a known hostage or standoff situation.

Are there any health risks associated with TTWS device operation?

No. TTWS devices can be considered low power radios for health and safety purposes.

Will TTWS devices interfere with cellphones or radios?

No. The frequencies utilized are not within connected or neighboring bands with other communication devices. In addition, TTWS devices transmit at low power outputs.

How do TTWS devices work?

TTWS devices operate via electromagnetic signal (i.e., radio waves). TTWS devices transmit RF energy and monitor the reflected energy to detect motion. This concept is similar to the manner in which police use a traffic speed gun to monitor the speed of a moving vehicle.

Are there different kinds of TTWS devices? What is the difference between 1D vs. 2D TTWS devices?

Some devices provide one-dimensional (1D) information, which includes range and status (moving/breathing) of a target, while others provide a two-dimensional (2D) graphical display of multiple targets. This display can include the general shape and layout of a room, other solid structures within a room, and can detect the number and placement of items moving within a structure. Most 2D devices will only detect up to three persons in motion at one time.

What will TTWS devices detect? Animals? Objects such as fans?

TTWS devices will detect all motion, including trees and animals such as household pets. Smaller animals have a weaker radar cross-section and are not always detected. Even motion from inanimate sources, like fans and moving curtains, can trigger TTWS device detection.

Be aware of the environment, including your own team's position. Even when positioned behind the TTWS, movement from team members can sometimes result in false signals.

Will TTWS devices detect an injured or sleeping person who is not moving?

TTWS devices report the ability to detect breathing. This is accomplished through detecting the motion of the chest upon inhale/exhale. However, successful detection is dependent on the amount of motion and its relative orientation to the device. As a result, a person who is a shallow breather, resting or in a prone position (e.g., sleeping) might not be detected.

Will TTWS devices detect more than one person?

Yes and no. All TTWS devices detect the signals from multiple targets. However, 1D devices only display the range to the target with the strongest RF return signal. Occasionally, an operator may see the display flash back and forth between two ranges, which can be an indication of more than one target in a room. This is not a reliable indicator, however, and should only be considered in an advisory capacity. 2D TTWS devices that present a map will display multiple targets up to the device limit (typically three limited to different simultaneous targets).

Do TTWS devices show an image of the person or object within a structure?

No. TTWS technology uses radar signals, not visible light or infrared optical methods; therefore, the devices are extremely limited in spatial details.

Where and what types of structures and places are TTWS devices less useful?

Detecting persons in houses is easier than apartments. Apartments, such as public housing with thick walls, often use rebar and metal doors. Newer office buildings and office construction use metal wall studs, which might interfere with measurements. Mobile homes are often constructed with solid aluminum exterior walls and therefore will block radar signals; they are the least suitable for TTWS.

Do TTWS devices operate through metal surfaces?

No. TTWS devices will not penetrate solid metal surfaces including walls, doors and home siding. This limitation even includes thin metal surfaces, like metal-backed insulation or some mobile home walls. Structures with internal support, such as rebar or chicken wire, may or may not allow operation, depending on the spacing of the metal as well as placement of the TTWS with respect to the metal.

How thick of a wall will TTWS devices penetrate?

TTWS devices easily penetrate most common building materials, including concrete, wood, brick, glass, adobe, etc., with thickness of up to 12 inches. The thicker the wall, the more signal loss (attenuation); this will result in longer measurement time (i.e., lag in the display of relevant results). The thickness and type of materials can affect the accuracy of the measurement as well.

Can TTWS devices detect through multiple walls?

TTWS devices can detect through multiple walls, floors and ceilings up to the depth noted within operational parameters. If the building structure is known, a trained operator can often determine whether a person is in a back room or a front room.

What can be done to better detect through home or office walls?

Some TTWS devices are designed to be held in a horizontal mode during operation; however, rotating the device 90 degrees (vertical) will often help an operator miss wall studs or other blocking objects.

How long should a scan take?

Although the depth of the scan affects the time of detection, it should take less than a minute for results from current commercially available systems.

What types of items affect TTWS device operation?

TTWS have limited field of views and can be blocked by certain items (e.g., metal); moving to various points along a wall can only help to develop a more complete understanding of the interior.

TTWS detects all motion, including trees and animals; therefore, always be aware of the whole environment.

Porous concrete blocks can absorb water from humid environments, which can sometimes affect the operation of a TTWS.

Do not move the device while scanning. The TTWS radar works by relying on the reflected signal returning to its exact point of origin to produce accurate measurements.

If one receives a jumping measurement (e.g., Moving and then Breathing; 7 feet distance and then 20 feet distance), then it is likely caused by metal interference (rebar, insulation backing).

Are there times when a TTWS device would not detect a person?

TTWS devices may miss a person standing immediately against the other side of the barrier wall, interpreting them as part of the wall by mistake.

TTWS devices cannot detect people hiding behind metal objects such as refrigerators, washers, dryers, etc.

Poured concrete walls thicker than 12 inches, such as those in parking garages, are too thick for TTWS to detect motion.

How large an area do TTWS devices cover? How far away does a TTWS device detect people?

Each type of TTWS device has different operational parameters, including field of view and distance. Detection range is dependent on exterior (and interior) wall material type and thickness, as well as the nominal range of the specific device. Currently, commercially available systems have Fields of View of 120 to 160 degrees and Maximum Ranges of 15 to 20 meters (50 to 65 feet).

Can a TTWS device scan a whole house or room?

TTWS devices have a conical field of view that will incorporate motion from both azimuth and elevation. TTWS devices detect moving targets within a specified angle and out to a certain distance. This enables an entire room to be covered in a single scan. A cone will extend +/- degrees in both the horizontal and vertical axis from the scanned point. This means that both walls and the ceiling of multiple story structures will be scanned. Scanning a two-story house will detect motion on the second floor, as well as on ground level. Depending on the size of the room being scanned, TTWS devices will likely detect motion beyond the room to potentially include the far exterior of the structure.

Taking multiple measurements at different places will establish a more reliable understanding of the interior structure.

Can TTWS devices operate in a stand-off mode, without holding them against a wall?

Some TTWS devices have been designed to easily operate in a standoff mode, while other TTWS devices will often work successfully in a standoff mode if the device can be kept motionless by the operator.

Do I need training to use a TTWS?

Yes. All operators should receive instructional training from the vendor or from an experienced user (i.e., train-the-trainer approach). In addition, although some interfaces are simple and appear to require no advanced training, practicing and learning how to use a TTWS device is always recommended so that you can interpret the signal and use the device effectively in the field. As with all tools and devices, practicing in the same manner and environment as the device would be used operationally is recommended.

How often should the batteries in a TTWS device be maintained?

Although some TTWS devices have a low-battery indicator, there is often a short time period between low battery being displayed and the device running out of power. Replacing batteries often and having replacement batteries handy is recommended. Many TTWS devices recommend a specific type of battery for optimal performance (e.g., Energizer lithium L91 batteries).



6.0 References

The SSBT CoE gathered and developed information in this report from a number of sources.

- The SSBT CoE carried out extensive test and evaluation (T&E) of commercial and prototype TTWS devices in operationally relevant scenarios and environments. This work included different target behaviors, a range of structures and walls, and various environmental factors. The results of the T&E are to be published through www.justnet.org in early 2014.
- Discussions between the SSBT CoE and representatives of criminal justice agencies:
 - Gwinnett County Sheriff's Office (Lawrenceville, Ga.).
 - Cobb County Sheriff's Office (Marietta, Ga.).
 - U.S. Marshals Fugitive Task Force (Washington, D.C.).
 - Plano Police Department (Plano, Texas).
 - Sacramento County Sheriff's Department (Sacramento, Calif.).
 - Virginia State Police.
 - South Carolina Law Enforcement Division (SLED).
- Criminal justice practitioner and vendor engagement through technology demonstrations and workshop meetings at various events:
 - NIJ Sensors Technology Working Group Meeting (April 19-20, 2011, Arlington, Va.).
 - Atlanta TTWS Technology Demonstration (Aug. 23, 2011, Lawrenceville, Ga.).
 - HIDTA-SW TTWS Technology Demonstration (Feb. 14, 2012, El Paso, Texas).
 - Mock Prison Riot (May 7-8, Moundsville, W.V.).
 - NIJ Annual Conference (June 18-20, 2012, Arlington, Va.).
 - Fairfax Technology Demonstration (July 25, 2012, Fairfax, Va.).
 - DHS SAVER TTWS Practitioner Focus Group (Dec. 11-12, 2012, Charleston, S.C.).
 - Atlanta TTWS Field Testing (Jan. 15-16, 2013, Lawrenceville, Ga.)

- El Paso DHS TTWS Technology Demonstration (March 8, 2013, El Paso, Texas).
- DoD Operations in Urban Environments Workshop (May 22, 2013, Quantico, Va.).
- NIJ Technology Institute for Law Enforcement (2011, 2012, 2013).
- NIJ Technology Institute for Rural Law Enforcement (2011, 2012, 2013).
- Additional supplemental documents and reports on TTWS:
 - ManTech International Corporation, *Through-the-Wall Sensors for Law Enforcement: Market Survey*, <https://justnet.org/pdf/00-WallSensorReport-508.pdf> (October 2012)

Appendix: Acronyms and Abbreviations

ACRONYM	DESCRIPTION
1D	One Dimensional
2D	Two Dimensional
CFR	Code of Federal Regulations
CoE	Center of Excellence
DOJ	Department of Justice
FCC	Federal Communications Commission
NIJ	National Institute of Justice
NLECTC	National Law Enforcement and Corrections Technology Center
NTIA	National Telecommunications and Information Administration
SSBT	Sensor, Surveillance, and Biometric Technologies
T&E	Test and Evaluation
TTWS	Through-the-Wall Sensor
U.S.	United States

