Texas A&M Engineering TEEX Extension Service

2024 TEST REPORT

Texas A&M Engineering TEEX Extension Service TESTED

TEEX-Tested Report for

InVeris Training Solutions™

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TEEX-Tested® Report: InVeris SURVIVR VR Law Enforcement Training System

Submitted to InVeris on behalf of the Texas A&M Engineering Extension Service (TEEX) Testing and Innovation Center (TT&IC):

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Summary of TEEX-Tested Results for InVeris SURVIVR VR Law Enforcement Training System

Immersive environment	The InVeris SURVIVR VR Law Enforcement Training System provides 4 categories of environments that each contain 18 – 39 different scenarios. The system includes a combination of video and sound immersion that simulates a high-fidelity experience.
Equipment realism	The physical devices provided by InVeris are used to give the user a feel for the tools that they will be using in the field. This includes: - A prop handgun that can be a replicate of the issued handgun of the department - Prop Shotgun or AR style rifle - Prop OC Spray - Prop duty flashlight - A prop taser similar, to the issued taser model of the department
System operation	The system can be set up by two people in 45 minutes in an open room. Scenarios can last from 30 seconds to indefinite. One Instructor/operator can operate the system. The TT&IC recommends using two operators for complex interactions and two people on the play boundaries for safety.
Reliability	System reliability is good. Noted issues with longer play periods with random devices requiring reconnecting. The InVeris technical support was helpful in assisting with troubleshooting and accepted feedback for software improvement releases.
Ease of use	Operator and user controls take one session to learn the basics. Users tended to learn the controls in < 10 minutes.
Scenario realism	The scenarios, environments, reactions, and devices provide an operationally realistic environment that law enforcement officers encounter and use in operations. Instructor/operators can modify, enhance, and/or create scenarios. Preplanned or dynamic responses/reactions can be injected as appropriate or desired.
Learning objectives	Although primarily a de-escalation trainer, the system supports boarder scenarios involving decision making and department procedures and policy training.
Safety	The system provides a safe environment for trainees to become immersed in a realistic scenario. Safety observers are highly recommended at the edges of the training area to prevent participants from running off the play area and hitting outside obstacles.
Cost/Return on investment	VR training systems offer environments and scenarios that would be expensive and risky to replicate in physical areas. Numerous environments can be simulated and executed in a short training period using the same location.

Acknowledgements

This TEEX Tested Report could not have been accomplished without the help of the local and state Law Enforcement departments and agencies. We would also like to thank the Bush Combat Development Center (BCDC) for their generous help with providing space and resources for a portion of the operations test conducted with the InVeris training system. This TEEX Tested Report was written by TT&IC staff including Director Ray Ivie, Technology Evaluator Mike Avolio, and Graduate Student Workers Joshua Krueger and Robert Mount.

Texas A&M Engineering Extension Service (TEEX) Testing & Innovation Center (TT&IC) conducts performance assessments in operational environments by experienced professionals using representative facilities and environments the product is expected to perform in. Operators perform functions that are expected in operational service and assess the products and solutions using the manufacturer's guidelines and instructions to assess performance. TEEX tests follow a process including standards reviews, metrics development, expert panel reviews, test plan and scenario development, and quantitative and qualitative measurements and surveys. This report is a summation of the functionality, reliability, and performance results.

The InVeris SURVIVR VR training system and its capabilities have been TEEX-Tested(R) based on the specific methodology presented in this report. TEEX hereby disclaims and any recipient of this report waives any warranties, whether expressed or implied, including without limitation and implied warranties of merchantability, fitness for a particular purpose, or non- infringement. Any recipient of this report accepts the report "as is" and acknowledges that TEEX has no responsibility or liability to the recipient. This report does not constitute an endorsement by TEEX.

TEEX-Tested® Report for InVeris
Conducted by:
TEEX Testing and Evaluation Center (TT&IC)
Texas A&M Engineering Extension Service (TEEX)

Distribution: Open

Executive Summary

The Texas A&M Engineering Extension Service's Testing and Innovation Center (TT&IC) conducted a TEEX-Tested® assessment of InVeris SURVIVR VR Law Enforcement Training System to provide training and acquisition decision-makers with information regarding the product's operational performance. TEEX-Tested assessments follow a similar process to Military Utility Assessments (MUA) to assess the technology's performance in an operational setting. Professionals representing the targeted user base participated in the assessment.

InVeris' SURVIVR is a Virtual Reality (VR) training system that combines virtual visual and sound environments with hands-on gear to provide an immersive experience. SURVIVR is marketed as a de-escalation trainer for law enforcement officers. The TT&IC received the 2023 system to conduct an operational assessment using TEEX law enforcement training and curriculum staff and municipal and state active law enforcement officers. Assessments were conducted using Texas Department of Public Safety, Texas Alcohol Beverage Commission, Round Rock, TX Police, Bryan, TX Police, College Station, TX Police and Texas A&M University Police officers currently performing in highway, traffic, SWAT, patrol, investigation, enforcement, and training disciplines.

Although marketed as a de-escalation trainer, the scenarios, virtual environments, and instructor/operator injects allow for training beyond de-escalation. The system evaluated included two-person capability/immersion and interaction. Equipment included two kits, each with a VR headset, graphics computer with InVeris Software, laptop for operating/managing the total system, scenario selection and tailored scenario development, VR tracking towers, an M4 rifle, Glock 19 pistol, pepper spray, flashlight, and TASER. All the duty gear is operative in the VR environment for a fully immersive experience. A law enforcement duty belt is recommended to allow players options during encounters and incidents. The operating system can be connected via HDMI to an optional TV monitor for other observers to see a player's view. A monitor with a picture in a picture (PiP) capability could be used to alternate between two players' views. The system is transportable in two wheeled hardcases and two desktop computer boxes. An indoor area with a minimum of 10-foot x 10-foot and a maximum of 35-foot x 35-foot unobstructed area with electrical power is needed for training.

As a result of reviewer and participant feedback and overall testing, we conclude that the InVeris SURVIVR VR Law Enforcement Training System performs as designed and can provide training and ongoing education to the law enforcement professions. Our assessment concludes:

- A larger space allows for a more realistic use of the environments and interactions, especially when using two SURVIVR participants;
- Scenarios can be created or are tailorable for interactive avatar suspects, crowds, objects placed in scenarios, distractions, and player start location;
- Scenario environments included traffic stops, bar and retail establishments, domestic disturbances, suicidal incident, demonstrations, active shooter environment and disorderly conduct are realistic and provide environments for de-escalation education and assessment as well as useful additional training in policy and procedure decision making.

Contents

Introduction

The following TEEX-Tested report represents findings of operational test results to meet the needs of law enforcement professionals at the local, state, and federal levels. The Texas A&M Engineering Extension Service Testing & Innovation Center (TT&IC) leverages TEEX facilities; national and organizational standards; TEEX instructors; TEEX students; and local and state law enforcement officials during testing. The TEEX-Tested mark is TEEX's premier offering for designing and executing testing for disruptive and innovative technologies and is a sign that a technology performs as intended under acceptable, repeatable, and real-world conditions.

This report provides an impartial third-party product evaluation of InVeris SURVIVR VR Law Enforcement Training System. This assessment was performed according to our seven step TEEX-Tested methodology from May 2023 through October 2023 at TT&IC located at 101 Gateway Blvd, College Station, Texas, 77845, and the Bush Combat Development Complex (BCDC) at 717 RELLIS Parkway Bryan, TX 77807 and includes evaluation of the InVeris SURVIVR VR Law Enforcement Training System under operational conditions by users of various experience levels including Subject Matter Experts (SME).

The InVeris SURVIVR VR Law Enforcement Training System is currently being used in training for police departments across the United States of America. InVeris developed this immersive VR system as a safe and cost-effective solution that attempts to recreate the stress and response needed for real-world law enforcement scenarios that officers are likely to encounter in the field. The dangers of law enforcement scenarios are difficult, time consuming, and expensive to recreate, therefore the InVeris SURVIVR VR Law Enforcement Training System is an option for law enforcement entities to utilize to effectively train officers. InVeris describes the product as:

An advanced training solution that uses virtual reality (VR) for critical, real-world preparation for de-escalation of force situations. SURVIVR provides law enforcement agencies, private security firms, and military security forces cutting-edge VR technology to rapidly improve trainees' communication skills, decision-making ability, adherence to policies and procedures, and situational awareness.

Our evaluation involved both single and dual participant scenarios in the VR environment. There is a plethora of scenarios in which the instructor can choose to accommodate either a single officer scenario or a dual officer scenario.

As no operational field test can include all applications and scenarios that could be encountered, a representative set of testing criteria, conditions, and VR environments were selected and used to collect data, observations, and end user feedback. The sections that follow outline the methodology and test plan utilized during the InVeris product evaluation, as well as observations, results, and takeaways.

System Components and Setup

Hardware

The InVeris SURVIVR VR Law Enforcement Training System is comprised of multiple hardware and software components designed to deliver virtual visual and sound environments with hands-on gear to provide an immersive experience. Components listed below are standard with the SURVIVR VR Law Enforcement Training System. There are customized pieces available from the manufacturer upon request. The two-operator system, shown in Figures 1 and 2, consists of the contents contained in two impact-resistant wheeled 31.5" X 20.5" X 12.5" hardened cases and two mid-tower computer boxes. The InVeris system consists of the following components:

Figure 1 InVeris Pelican Case Contents

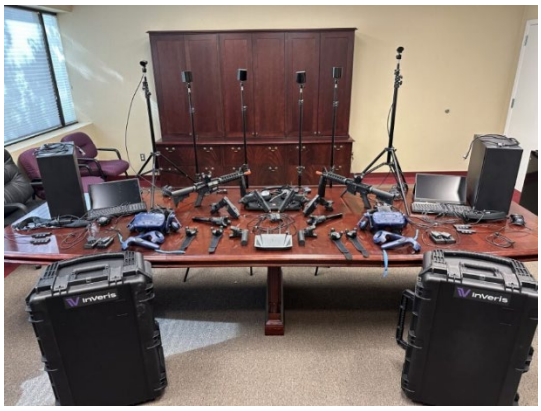

Figure 2 InVeris SURVIVR Full Layout for Two-

* InVeris additionally offers both a Haptic feedback vest and a heart rate monitor for the SURVIVR system at an extra cost. These were not assessed by TT&IC and are not included in this report.

Two hardened shipping Cases

Computer Systems

- 1 Trainer Laptop
- 2 Trainee PC's
  - Two keyboards
  - Two Computer Mice
  - Two Portable Monitors

Virtual Reality System Components

- 4 VIVE Headset Batteries
- Two VIVE tracking poles with sensors.
- Four SteamVR Tracking poles **&** sensors.
- Four SteamVR Tracking poles **&**sensors.

Peripherals & Cables

- 1 Wi-Fi router
- 4 VIVE USB Docks
- 14 VIVE USBs
- 2 PC Power Cables
- 4 VIVE Battery Chargers
- 12 VIVE Sensor Chargers
- 2 Ethernet Cables
- 1 Router Power Cable
- 4 SteamVR Tracker Cables
- 2 VIVE Trackers Cables
- 2 HDMI Cables
- 2 VIVE Headset USB Cables
- 2 VIVE Headset Battery Cables

Participant Components

- 2 VIVE VR Headsets
- Tools (**per** Trainee system)
  - Armalite-style rifle
  - X26P TASER
  - OC Canister
  - **2** Hand Trackers
  - Glock 19 handgun
  - D Battery Flashlight

System Setup

Proper deployment of the InVeris SURVIVR VR Training System requires all components included in the cases. Safe use of the system requires a space of at least 10ft x 10ft up to a maximum of 35ft x 35ft. Proper operation of the system requires 120-volt electrical receptacles for operation. The system can only operate when both PCs are assembled and connected to the monitors and the Wi-Fi router using the provided cables. These PCs are then connected to the instructional laptop.

The assembly process (from unboxing to running the application) took two personnel approximately 45 minutes. Disassembly of the system took two personnel approximately 15 minutes to complete. InVeris provides detailed documentation to guide the system setup. Users also have access to the *Knowledge Base* folder on the instructor's laptop for a full instruction manual, including assembly and disassembly instructions.

Standard room setup involves placing the SteamVR base stations at the four corners of the testing area in accordance with the setup manual. The SteamVR system can then be calibrated to the room as the computer system is now connected to the necessary sensors. The entire setup is aided by the InVeris Training Solutions online technical support team and a manual is provided as well in the case that a system needs to be moved for any reason. Assessments were primarily conducted using a 15ft x 15ft (225 sq ft) play area at the site pictured in Figure 3. For the final series of testing, the InVeris system was conducted at the Bush Combat Development Center (BCDC) using a 35ft x 35ft (1,225 sq ft) play area pictured in Figure 4. This system move was also intended to evaluate the software in a larger environment and a second disassembly/reassembly of the training system.

Software

Figure 3 TT&IC Room Setup (225 sq ft)

Figure 4 BCDC Room Setup (1,225 sq ft)

All environments can manipulate the weather, time of day, and the starting positions of the trainee(s), suspect(s), and bystander(s). Furthermore, when creating or modifying a scenario, drag-and-drop props (e.g., contraband, weapons) can easily be added to the environment. Available environments are shown in Table 1. Along with the environments each scenario has the following options for customizing the suspect(s):

- 1 Suspect Option
- 2 Suspects Option
- 173 Different Suspect Appearances
- 12 Different Idle States
- 12 Different Starting States
- 3 Less-Lethal Behavior Options
- 3 Different Target Options
- 10 Different Possession Options
- 15 Unique Voice Sets (Not including Race differences)

Instructors/Operators can inject events in some scenarios during the action. These include loud noises, crowd heckling, and subject specific actions requiring immediate actions by the participant.

Table 1 Table of Environments in InVeris SURVIVR

Categories			
Generic	Traffic Stop	Riot/Protest	Gate Runner
Environments			
Holding Cell Commissary Alleyway6 Camp Pendelton Gate Parking Lot HQ Office Bar Visitor Center Backyard Reagan Exterior Motel Reagan Interior Rooftop Base Housing Residential Garage Flight Line Gas Station School Segment(s) 1 - 4 Underpass Courtroom Pawn Shop Emergency Room School Trailer Park School Pick-Up Playground Alley 2 Jail Bank 2 Prison Yard Bank 3 Emergency Room 2 Apartment Chapel Bridge Bank	Alleyway Bank Parking Lot Camp Pendleton Gate Motel Reagan Exterior Rooftop Flight Line Residential Garage School Pickup Gas Station Alley 2 Underpass Bank 2 Trailer Park Bank 3 Playground Bridge	Holding Cell Commissary Alleyway Camp Pendelton Gate Parking Lot HQ Office Bar Visitor Center Backyard Reagan Exterior Motel Reagan Interior Rooftop Base Housing Residential Garage Flight Line Gas Station School Segment(s) 1 - 4 Underpass Courtroom Pawn Shop Emergency Room School Trailer Park School Pick-Up Playground Alley 2 Jail Bank 2 Prison Yard Bank 3 Emergency Room 2 Apartment Chapel Bridge Bank	Camp Pendelton Gate

Methodology

Scope: The purpose of this evaluation is to conduct an impartial third-party assessment of the InVeris SURVIVR VR Training System in a realistic and safe training environment with multiple users of various skill and experience levels. The overall objective is to assess the quantitative and qualitative aspects of the product and its potential training value and purposes. This evaluation is based on the knowledge, experience, and feedback of SMEs (Subject Matter Expert) and quantitative and qualitative data collected during testing.

The TEEX-Tested methodology is based on a seven-step protocol designed to assess technology in the appropriate testing environment that ensures the product functions as intended and will function in the appropriate contexts. Figure 6 provides a diagram of the TEEX-Tested journey and an explanation of the seven-step process as applied to the InVeris SURVIVR system.

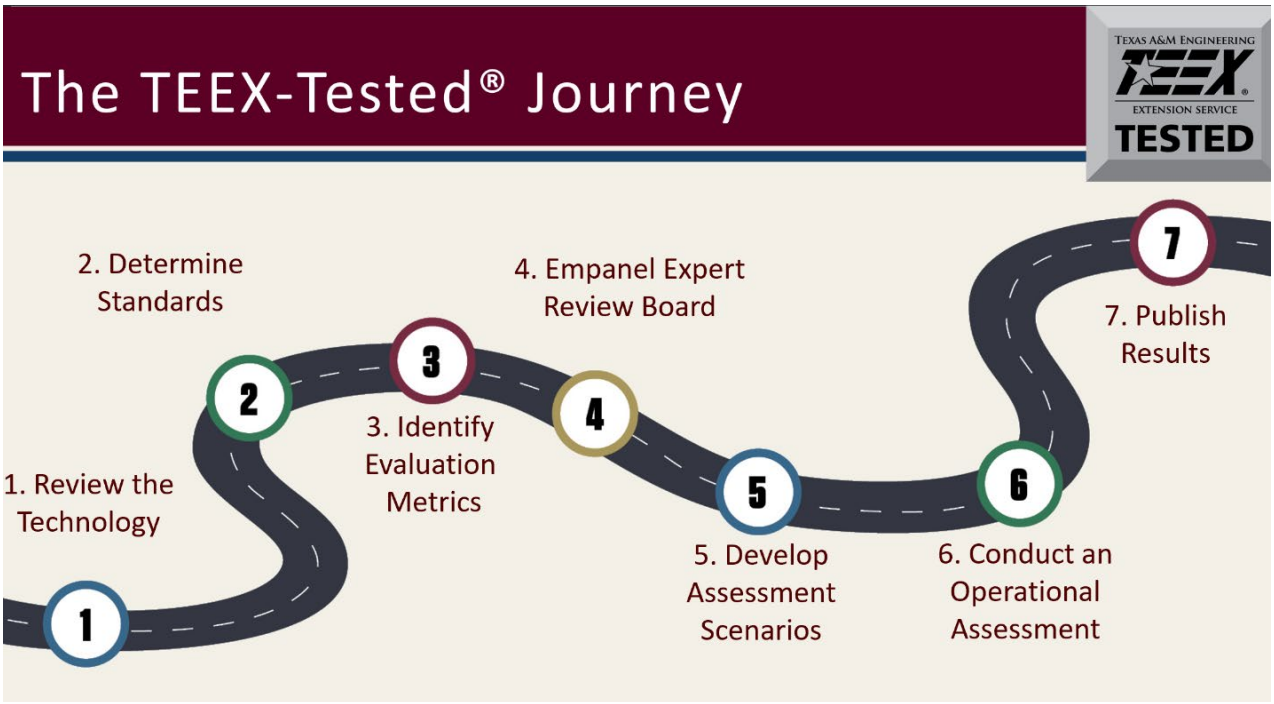

Figure 5 TEEX-Tested assessment process

Step 1 – Review the Technology:

- The TT&IC team reviewed InVeris installation guidelines, user manuals, and instructions provided via software applications, such as SteamVR, to begin system operation.
- The physical tools (weapon simulators/ tracking) were also analyzed by the team to determine their realistic portrayal and functions of their actual counterparts.

Step 2 – Determine Standards:

- The TT&IC team determined the standards by which the product would be evaluated and identified applicable evaluation metrics that would allow proper analysis of the technology to be tested.

Step 3 – Identify Evaluation Metrics:

- In conjunction with the Institute for Law Enforcement and Protective Services Excellence (ILEPSE), the Texas A&M Engineering and Extension Service (TEEX), and the Bush Combat Development Center (BCDC), the TT&IC team determined that the evaluation metrics will consist of quantitative, qualitative, and other metrics to best evaluate the product.

Step 4 – Empanel Expert Review Board:

- The panel of SMEs consisted of law enforcement officials and training developers involved in law enforcement at the state, local, and university level. SMEs were selected to participate and provide their assessments of law enforcement procedures, policies and tactical use in the virtual reality training system.

Step 5 – Develop Assessment Scenarios:

- The TT&IC team assessed existing scenarios, modified scenarios, and created realistic, fair, and impartial testing scenarios leveraging TEX and BCDC facilities and appropriate standards and evaluation metrics.

Step 6 – Conduct an Operational Assessment:

- The TT&IC team conducted operational testing on the product in a realistic and safe training environment with multiple users of various skill and experience levels and collected the resulting data, observations, and end user feedback for analysis.

Step 7 – Publish Results:

- This comprehensive TEEX-Tested report captures, interprets, and communicates all the relevant data and completes the final step of the protocol.

Location

The testing of the InVeris SURVIVR VR Training System was conducted at the TEEX Gateway facility in College Station, TX. A secondary test was done at the Bush Combat Development Center (BCDC) at Texas A&M University System's RELLIS campus to test the 35ft x 35ft play area with the InVeris system.

Test Plan

The detailed test plan describing the test strategy, objectives, schedule, and metrics used can be found in Appendix A. The test plan used to evaluate the of InVeris SURVIVR VR Law Enforcement Training System was developed similarly to those used in industry and the military but was tailored to the unique characteristics of a VR training system evaluated in realistic conditions by users of all ability, skill, and experience levels. It was determined that this evaluation would not focus on the specific technical aspects of the hardware and software, but on its performance as an overall system and its purpose and utility as a training option.

Sequence of TEEX Testing Events

1. InVeris setup and operational training for TT&IC staff
2. Initial tests with law enforcement officials for review and assessment
3. Executive demonstrations (TEEX executives and curriculum staff)
4. Data collection (battery life, average scenarios, setup)
5. Continued review and assessment with state and local law enforcement
6. Equipment moved to BCDC for further testing.
7. Additional testing with state law enforcement
8. Testing concluded.

Analysis and Results

The metrics measured in the TEEX-Tested assessment are grouped into three categories: quantitative metrics, qualitative metrics, and other value considerations. This section details the observations made and the subsequent results of the assessment.

Quantitative Metrics

The TEEX-Tested quantitative metrics are a set of defined measurements that provide an objective perspective to the evaluation. Quantitative metrics are typically reported using numerical data.

Setup Time/Ease of Setup: Two adults can set up the system, from boxed to running the software, in 45 minutes in an open room.

Room Requirements: The software dictates a minimum of 10ft x 10ft space with the potential to expand to 35ft x 35ft. The room should be an open room, free of any tripping hazards. The room should not be in direct sunlight and should not contain reflective surfaces. When choosing the actual VR training floor dimensions, a 5 ft buffer zone is recommended around the play area to minimize risk of wall or tripping hazards and for access to all the system components without stepping onto the designated VR training area. **Number of Instructors Required:** The InVeris system can be facilitated by one instructor, but having an additional instructor to verbally play the role using the suspect avatar is preferred. Additionally, safety assistants are recommended as well. The safety spotter is recommended to ensure the user does not leave the safety zone and bump into a wall or other obstacle in the training area.

Power Requirements: Access to at least four 120/240 power outlets. Extension cords are potentially necessary for each tracking tower. A power strip cable is also required for the host PC, trainee PCs, and the router.

Battery Life: The battery attached to the headset was determined to last about three hours on a fully charged battery. The internal battery of the hand trackers and trackers attached to the props was determined to last approximately eight hours on a fully charged battery.

Battery Recharge: The batteries for the headset take approximately 2 - 3 hours to recharge to a full battery status. The batteries attached to the VIVE trackers take an average of 1-3 hours to recharge, depending on the voltage used (USB vs. wall plug (less time)).

Startup Time: It takes an average of 5 minutes to start the VIVE software, SteamVR software and base stations, then the InVeris software. Depending on the number of trackers, this time could vary.

System Load Time: It takes approximately 5 seconds to load scenarios or change settings and options within a scenario.

Average Scenario Length: The average de-escalation scenario is between 2-5 minutes, although there is the possibility for both longer and shorter encounters. The type of scenario, the questions asked by the officer, and how responsive/aggressive the suspect is will influence the length of the scenario. However, due to the scale and detail of the environments, scenario play can extend for long periods, depending on the instructor's desires.

System Stability and Reliability: The system required frequent restarts throughout the evaluation. These restarts were most commonly the result of one or more trackers failing to function or triggering a separate device altogether. When this occurred, the TT&IC team restarted the InVeris application along with both SteamVR and VIVE. If the issue persisted, all computers would be restarted. This situation is expanded upon in the 'Functionality of Equipment' section below. Other situations which required the system to restart were failures to render area, system freezes, and loading the user above or below the digital area. *Note: reflective areas, such as multiple large windows may affect IR signal reflection causing tracker failure.*

Frame Rate: There was no available information regarding frame rate in the manufacturer's documents provided. No noticeable flicker or latency was noted by the test team or participants.

Resolution/Refresh Rate: The resolution of the VIVE headset is 1440 x 1600 pixels per eye. The refresh rate is 90Hz.

Tracking Accuracy/Latency: Sunlight was determined to interfere with the tracking accuracy when in contact with the tower sensors. This includes large reflective surfaces, such as uncovered windows. In addition, when operating in larger play areas, failure to maintain line of sight between the tower sensors and the VIVE headset will result in blue screen flashes. Latency was rarely determined to be an issue.

Measurables to Determine Success in Training Scenarios: The measurables to determine individual user success during training scenarios are logical and flexible. Aside from a standard de-escalation success, other examples of potential measurables are firearm accuracy, hostage rescue, discovery of contraband, and the time elapsed to successfully complete the scenario. An instructor/operator can also evaluate tactics, techniques, and procedures through observation.

Control of Avatars: Operators have limited, but adequate control over suspect avatars' physical and verbal responses. Operators may move the suspect anywhere in the digital space in any position but are unable to make fine adjustments such as their facing orientation. Automated verbal control over suspects is limited and requires the operator to be familiar with selecting the most appropriate response tree. Furthermore, the response options frequently demonstrated unexpected outcomes due to their vague titles (e.g. "Refuse to provide information" prompts suspect to say, "I don't have my license" when the Officers question was "Where are you headed?"). Because of these inconsistencies, the TT&IC Team strongly preferred to utilize the instructor-microphone to speak to trainees; sparking faster dialogue and promoting more accurate responses. Bystander avatars have very limited control as the operator can only select actions and not their location or path in the digital space. This resulted in encounters where innocent bystanders would run directly towards officers during active shooter scenarios as they were attempting to flee from the gunman. Moreover, fleeing bystanders also would subsequently walk back into active shooter situations.

Functionality of Equipment: As stated in the 'System Stability and Reliability' section above, the tracking equipment was subject to failures to function during testing. During long play periods the tracking devices continued to have failures or trigger a separate device after 1-5 consecutive scenarios, requiring a restart. The TT&IC team met with InVeris technicians to troubleshoot the issue and it was determined that sunlight may have interfered with the tracking devices.

Qualitative Metrics

The TEEX-Tested qualitative metrics are a set of measurements based on human judgement that subjectively evaluate a product and or its technology. Qualitative metrics result in observed categorical descriptive data:

NONE	FEW	SOME	HALF	MOST	ALL
0%	1-24%	25-49%	50%	51-99%	100%

Mix of Scenarios Provided: Most of the scenarios provided were useful and saw frequent use in our operational assessments. Standouts include an active school shooter response, a vehicle search, and a suicidal jumper. The provided scenarios were valuable to familiarize the instructor with the capabilities of the system and promote environmental world-building later when creating scenarios.

Ease of Scenario Creation: Scenario creation was fast, intuitive, and repeatable. Instructors can edit existing scenarios or start from scratch. The process would benefit from the ability to create or alter the environments to have trainees stand behind cover or interact with vehicle doors. A minor

issue faced was the inability to determine what direction the avatars and trainee would spawn facing. Most of the participants stated that the scenario creation was easy to use.

Immersion: Immersion was established and broken throughout various scenarios. The most common reasons reported for a lack of immersion were users virtual wrists appearing broken or not correctly gripping a virtual tool, wrists point back at user, trackers and virtual tools floating away from the user, tools appearing to appear several feet away from the user when holding them, and occasional disorientating flashes due to a poor tracking connection. Additionally, several participants noted a physical interference with the magnified red dot on the VR rifle, as their proper cheek placement when aiming interfered with the VR headset. This made it difficult for the user to line up the magnified optic in real time. As stated, prior, the unpredictability of the suspects selected programed responses to an officer's questions broke immersion. Either the suspect would reply with something counterproductive, false, or with an unfitting tone/volume for the situation. One respondent commented that, "The computer-generated vocal delay takes away from the realism." This, along with the delay between the officer's question and the instructor searching for the most appropriate response, was suboptimal when compared to the instructor speaking via microphone.

Realism: Most participants stated that they believed the graphics, as shown in figures 7 and 8, were reasonably realistic and are only limited by the current VR technology climate. The behaviors of the

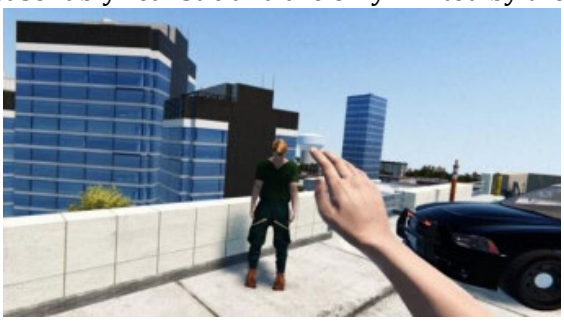

Figure 6 InVeris SURVIVR Operator VR view

Figure 7 InVeris SURVIVR Operator VR view handcuffing suspect

avatars were adequate for conversation-based training; however, physical indicators were sometimes confusing to trainees. Suspect body language is not predictable (apart from user-voice emotion functions) making it difficult to determine if they are concealing a weapon. Lack of detail in suspects hands resulted in officers being unsure what the suspect was holding. However, when suspects were directed to drop their held items, trainees on several occasions were immersed enough to believe they could pick up or move the dropped items, which is not possible. *Note: Being able to move the items away from the suspect into a patrol car would promote strong training habits, evidence collection methods, and general officer safety.* Regarding the trainees' tracking devices, the various tools functioned as expected when compared to their real-life counterparts.

Instructor Control/User Interface: Most of the participants stated that the instructor operations and user interface were easy to learn and operate. Trainees were easily accustomed to the VR space and instructors performed better operating after several repetitions.

Ease of Use: Most of the participants believed that the technology was easy to learn and operate. After the initial learning curve of how the technology operates, the system can be operated with strong levels of immersion and familiarity.

Audio Quality: Audio quality was effective throughout testing. Gunshots, verbal interactions, vocal clarity, microphone recording, and ambient noise were all distinguishable and clear. The ability to include auditory distractions, such as fire alarms or truck horns, are great additions to increase

variability between scenarios. The inability to distinguish separate suspect voices when using the instructor microphone is less than optimal. While providing more accurate and timely responses, the instructor microphone tended to confuse trainees when placed into scenarios with two suspects as they could not accurately determine who was speaking.

Perceived Value of InVeris VR weapon simulators: The weapon simulators were physically comparable to their real-life counterparts and were able to mimic most of the functions expected. Racking the slide on the handgun and the charging handle on the rifle were both properly adapted to firearms. The firing of the weapons translated into VR visually and audibly, but some functions did not. For example, chambering a round, clearing malfunctions, and reloading were not options for the software to register. The trigger pull on the rifle and handgun operated as expected with a slight delay when translated to the virtual reality software (roughly ¼ seconds). The location of the tracking device on the handgun prevented a physical magazine reload option. While the TT&IC team received two InVeris VR weapon simulator Glock 19 clones and 2 AR-15 clones, other options are available to match the needs of various departments standard issue firearms.

Note: Feedback on how to improve the firearms mostly revolved around the magnified optic on the AR-15, as discussed above, and the absence of a reload mechanic. When the weapons are empty in the simulation, trainees audibly announce "Reload" to the instructor who will then press a "Reload" button for the trainee.

Perceived Value as a Tool to Develop Police Tactics, Techniques and Procedures (TTP): Department TTPs can be exercised and evaluated using the included scripts and/or by extending, modifying, or creating scenarios. While the focus of the system heavily benefits from de-escalation scenarios, force-on-force scenarios are available as well due to the flexibility and replay ability of the system.

Perceived Value as a Tool to Develop Decision-Making and Risk Management Skills: The scenarios place participants in realistic situations requiring on the spot decisions. In conjunction with the after-action report system, replays of the full session, and automatic or tagged events can be shown with audio and visual information to evaluate their performance.

Training Value for Rare and Difficult Scenario Exposure: Existing and created scenarios allow officers to be placed in situations that are difficult, expensive, or unsafe to replicate in live scenario play. Due to the flexibility of scenario creation, departments can create past or potential scenarios to evaluate actions and responses.

Perceived Value of InVeris Learning Outcomes: Students can be evaluated, instructed, and replay similar scenarios to improve performance in a safe and predictable/scripted environment. The scenarios and actions can be recorded, analyzed, and replayed with notations for debriefing. This is a valuable tool for instruction and improvement.

Other Value Considerations

This category includes critical considerations beyond measurable metrics explaining the perceived value of the system as a training tool.

Cost of Training: Students throughput is high, depending on the instructor's desires and debriefing plans. Environments and scenarios do not require physical environments and can be changed rapidly without relocation or maintenance of props. The SURVIVR training system can be used in multipurpose areas that are free of obstacles and are at least 15' X 15' but no larger than 40' X 40'. Lack of wear and tear of equipment and consumable supplies are advantageous. Additionally, most live action safety issues do not exist when using VR, except trip hazards and collisions with boundary walls.

Mobility and Storage: The InVeris SURVIVR system is packaged, transported, and stored in the provided Pelican rolling container and the provided computer box. Because the TT&IC had the two-trainee system, two Pelicans and two computer boxes can be seen below. When fully setup, the sensor poles cannot be disturbed or moved to avoid recalibration. The instructor should have a dedicated area set back from the play area to sit behind the computers and operate while maintaining line of sight of the trainee. After the initial SteamVR setup and room calibration, it is advised that the VIVE headsets and tracking pucks remain in the digital boundary to maintain connection with the sensors when powered on even between scenarios to avoid disconnects requiring reinitialization.

Durability: During operational testing, two devices were accidentally dropped by trainees at waist height on to a concrete floor resulting in breakage and failures to operate. One tracking device broke at the attachment point to a TASER device while the other broke the action on an OC Canister. Apart from these two instances, no other equipment exhibited any signs of wear/tear and is deemed unlikely to break.

Target Training Audience: Table 2 depicts the cumulative findings from the user feedback during testing. The section below will expand on these findings in greater detail as well as break them down by department.

Safety of Training Environment: Wires and other trip hazards need to be eliminated from the playing field. The play area must be open and free of obstacles, poles, or structures, as they are not seen/avoidable in VR. Some participants become immersed to the point that they lean on cars or visual structure that do not exist physically. Safety observers are highly recommended to prevent participants from running outside the play area into obstacles and walls.

Table 2 Cumulative User Feedback

	% Agree	% Disagree
Initial LE Training	87%	13%
Refresher Training	94%	6%
Expanding knowledge of law enforcement situations/environments	87%	13%
Street police*	93%	7%
Detective	60%	40% (6 N/A)
SWAT	61%	39% (8 N/A)
Recruiting & Retention	82%	18% (TABC Omitted)

Note: Research has shown that some participants experience nausea, disorientation, or dizziness while using the virtual reality systems (VR sickness). During the assessments, one participant became disoriented after a long play scenario (Chang, Kim, & Yoo, 2020).

Technical Support: InVeris Technical support was readily available via online and telephone support.

Maintenance: No maintenance other than recharging batteries and cleaning was required during our five-month assessment period.

System Longevity: VR technology and capability is changing and improving rapidly. InVeris SURVIVR software updates are available over the web directly, downloadable or provided by thumb drives, as desired by purchaser.

Training/Education Value: The VR system realistically places participants in decision-making situations requiring judgment, situational awareness, policy and legal aspects, and personal protection considerations. Capture and replay of the interaction provides instructors and students debriefing material to analyze and discuss actions and options.

Training Limitations: Department equipment may differ from the physical options available in the SURVIVR system. Additionally, sight picture on the rifle and handgun may differ from their issued firearms depending on the make/model of the optic. SURVIVR has a large library of scenarios and allows modifications and additions within the scenario staging and operations. However, body language, responses and aviators/ crowds may not act appropriately or noticeably to officer participants. Although the VR play areas are large, physical training space can limit participants from traveling to areas that they can see but are not in the physical play area.

User Feedback

Feedback was collected throughout the evaluation period. Also, surveys were administered at the end of each participant assessment session to capture feedback on testing. We received feedback from the Texas Department of Public Safety (DPS), the Texas Alcoholic Beverage Commission (TABC), College Station Police Department, Texas A&M University Police Department, Round Rock Police Department, Bryan Police Department, and TEEX Law Enforcement & Protective Services personal.

Assessment – Highway Patrol

The members of the Texas Highway Patrol participated in the system assessment. Seven members were asked to use the system at the TEEX Testing & Innovation site in the 15' X 15' (225 sq ft) play area configuration. Nine troopers participated in a separate assessment that used the 35' X 35' (1,225 sq ft) configuration at the Bush Combat Development Center. The second assessment was conducted to evaluate the utilization of a larger play space. Because of the difference in spaces, the responses will be reported separately.

Figure 8 Highway patrol participants looking at a simulated car

225 sq ft Configuration Assessment

Four of the seven participating highway patrol troopers indicated prior experience with VR technology. Most participants indicated the visuals were reasonably realistic with comments such as, "Somewhat cartoonish but good overall" and "Details like body language and objects in pockets would make the training more realistic".

Most respondents felt immersed in the scenario with the dissenting concerns regarding the size of the play area. The participants overwhelmingly voted that the interactive equipment operated similarly to their real-life counterparts. Similarly, the troopers voted unanimously that the scenarios were realistic; however, they felt they were limited to current VR technology regarding avatar reaction lag and that the realism of the scenarios would be significantly degraded with an inexperienced system operator. Equipment failures during the testing resulted in comments stating, "Consistent failure to correctly operate tools due to software issues sparked major setbacks." Most participants believed that learning occurred from the integration of the VR system and that it was easy to operate and teach from.

Similarly, most participants reported the system was simple to create scenarios, although several notes they would like to see an expansion of the catalog of actions, such as arrest/control tactics. The after-action replay (AAR) was unanimously found useful by the participants, with one commenting that, "This [was] in my opinion was the most useful part of the training, being able to review what the officer is looking at and where rounds traveled after shooting.". Table 3 provides a breakdown of the values evaluated by the officers:

Table 3 Responses of highway patrol using the 225 sq ft configuration

	% Agree	% Disagree
Initial LE Training	85%	15%
Refresher Training	85%	15%
Expanding knowledge of law enforcement situations/environments	66%	34%
Street police	80%	20%
Detective	0%	100% (4 N/A)
SWAT	0%	100% (5 N/A)
Recruiting & Retention	100%	0% (3 N/A)

1,225 sq ft Configuration Assessment

Nine members of the Texas Highway Patrol conducted a second session in a configuration using a 35' X 35' (1,225 sq ft) play space. Six of the nine participants indicated prior experience with VR technology. When asked if the visuals were reasonably realistic, most participants indicated the

visuals were reasonably realistic, while some stated they were not. Participants provided feedback stating the graphics were "…too jumpy, not smooth…" and "The movement of people models was erratic/jumpy. Every person moved as if they were drunk... ". Many participants did not feel fully immersed in the scenario, attributing their lack of immersion to operator lag and unrealistic automated responses by the system. Participants unanimously agreed that the scenarios they experienced were realistic and that the interactive equipment operated similar to their equipment. Participants recommended adding additional manipulation of the environment (such as closing car doors or moving objects). Most participants expressed that their actions, and the results following their actions, were reasonable. However, those who felt it was not representative of their actions cited the delay in the operator controlling the suspects responses to their questions. Using a live voice actor on a headset, responding as the suspect, solved the response issue for the participants.

Figure 9 Team scenario with inset participant view.

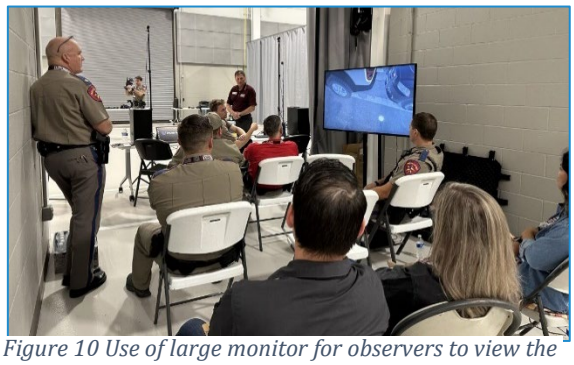

Figure 10 Use of large monitor for observers to view the participant POV

Troopers believed that the InVeris System operated as expected; albeit with recommendations to improve the sighting systems to represent and operate as their operational equipment. Participants in this assessment unanimously voted that the InVeris system was easy to operate and teach from, as well as being simple to create scenarios.

All respondents stated that the after-action replay was useful. When prompted for any potential changes they would like to see incorporated, respondents were mixed with their comments; while some thought the technology was sufficient, others expressed concerns over its current state. Weapon operational improvements were desired (magazine reloads, sights), but overall the weapons operated as expected. Troopers were concerned that non-playable bystanders would often ignore commands and run towards the officers. Table 4 presents a breakdown of the responses provided by the officers using the larger configuration.

Table 4 Responses of highway patrol using a 1,225 sq ft configuration

	% Agree	% Disagree
Initial LE Training	75%	25%
Refresher Training	80%	20%
Expanding knowledge of law enforcement situations/environments	71%	29%
Street police	80%	20%
Detective	50%	50%
SWAT	50%	50%
Recruiting & Retention	57%	42%

Assessment – State Law Enforcement Agency

Agents from the Texas Alcoholic Beverage Commission representing different regions of Texas participated in the TEEX Tested assessment. was conducted with 5 agents from different area offices. Two agents stated they had previously used VR technology for training. Agents unanimously agreed that the visuals were realistic and felt immersed in the scenario. An agent mentioned that the realistic environment provided by the system appeared to be "very video game-[like]." The agent also stated the operator lag and response time made it difficult to do certain tasks while in the simulation. Agents agreed the equipment operated like real equipment. One agent recommended that recoil and a more realistic trigger pull be added. The agents agreed the scenarios were realistic but were somewhat "cartoonishness" and noted the difficulty operating with two officers working in the simulation in the 15' x 15' (225 sq ft) configuration. Agents agreed learned occurred from the training and that the system would be a good tool for training.

Figure 11 Agent engaged in a scenario

There were mixed responses regarding ease of use and operation. Most agents noted they felt that use would become easier with more experience in the system and learning the design of the scenarios. Agents agreed that scenarios were easy to make. They noted there would be improvement with more preparation time. The agents only used the system 10-15 minutes on average to experience operating. The after-action replay was cited as being useful by every agent. Two agents suggested the InVeris system would help with recruiting and retention and they agreed that it would. The remaining four did not respond.

Table 5 provides a summary of the responses by the agents.

Table 5 State Law Enforcement Agent Responses

	% Agree	% Disagree
Initial LE Training	100%	X
Refresher Training	100%	X
Expanding knowledge of law enforcement situations /environments	83%	17%
Street police	100%	X
Detective	83%	17%
SWAT	67%	33%
Recruiting & Retention	N/A	N/A

Assessment – University Police Department

Figure 12 University Police Officer using the simulation

The departments tested independently from one another on separate days. Most of the participants had prior experience with VR systems with the majority citing prior law enforcement VR training. Based on their previous experience, most of the officers reported that the visuals were reasonably realistic and unanimously stated that they felt immersed within the scenarios. Most participants felt that the interactive equipment operated similarly to their real-life counterparts. Furthermore, all officers believed that scenarios were realistic, that their actions/results appeared reasonable, and that the InVeris equipment operated as expected. Recommendations consisted of the lack of realistic recoil and trigger reset. Participants believed that they successfully learned from the training.

All participants stated that the VR system was easy to operate and teach from and unanimously indicated that creating realistic scenarios was simple. After-action replay was overwhelmingly appreciated by the officers. When asked what they would change or add to the system, stronger vehicle interactions (open/close doors), firearm realism, and cleaner non player crowd movements were cited. Table 6 provides a summary of the university law enforcement officers.

Table 6 Summary of responses from university law enforcement

	% Agree	% Disagree
Initial LE Training	100%	X
Refresher Training	100%	X
Expanding knowledge of law enforcement situations /environments	100%	X
Street police	100%	X
Detective	78%	12%
SWAT	75%	25%
Recruiting & Retention	83%	17%

Assessment -Municipal Police Departments

The multiple municipal departments assessed the InVeris system. Officers who participated in the testing each stated they had prior VR experience, while some indicated for training or personal use. All officers reported that the visuals were reasonable realistic, with a majority stating they felt immersed in the scenario. Furthermore, all participants stated that the interactive equipment operated similarly to their real-life counterparts. All officers additionally reported that their actions appeared reasonable and that the scenarios were realistic. Participants stated that they learned from the experience.

Table 7 Summary of Municipal Law Enforcement

	% Agree	% Disagree
Initial LE Training	100%	X
Refresher Training	100%	X
Expanding knowledge of law enforcement situations / environments	100%	X
Street police	100%	X
Detective	50%	50%
SWAT	75%	25%
Recruiting & Retention	100%	X

The officers unanimously agreed that the system was easy to operate and teach from, that it was simple to create scenarios, that the catalog of actions was sufficient, and that the after-action replay was useful for reviewing performances. Table 7 provides a summary of their responses.

Assessment – Law Enforcement Instructors

The law enforcement instructor assessment included nine personnel representing the Texas A&M Engineering Extension Service (TEEX) administration and representatives of the TEEX Institute for Law Enforcement & Protective Services Excellence (ILEPSE). Half of these participants experienced VR technology for the first time with the InVeris SURVIVR system. Participants stated that the visuals were reasonably realistic, although subtle movements and alignment of tools could be improved. Each of the nine participants indicated that they felt immersed within the scenario and a majority felt that the interactive equipment operated similarly to real equipment.

Figure 13 Municipal officer using the simulation

Several participants commented on issues created by recalibration after a scenario concluded. In addition, most participants believed that the scenarios were realistic. However, they indicated they were not fully satisfied with the pre-programed responses for some suspects.

Most participants noted that the actions and results felt reasonable and believed that the InVeris equipment operated as expected. Participant feedback from this group was like other groups regarding the recalibration issues. All respondents noted that learning occurred from the use of the simulation, with one comment stating, "Yes! It makes training fun...".

Most of the respondents agreed that the VR system was easy to operate and use to teach activities. All respondents agreed that the system was simple to use to create realistic scenarios. When asked to comment on the catalog of actions within the scenario creation, one participant recommended, "A more robust approach would be to officer some additional engagement after handcuffing a suspect." Respondents unanimously agreed that the after-action replay system was useful with statements including, "Great tool! So much data from that." and "Yes – very major selling/teaching point". Table 8 provides the summary of the municipal law enforcement officers' perception of the value of the InVeris training system.

Table 8 Summary of Municipal Officers' Perceptions

	% Agree	% Disagree
Initial LE Training	63%	37%
Refresher Training	100%	0%
Expanding knowledge of law enforcement situations/ environments	100%	0%
Street police	100%	0%
Detective	100%	2 N/A
SWAT	100%	3 N/A
Recruiting & Retention	71%	29%

Additional comments included that the de-escalation priority intention of the SURVIVR system may not be best suited for SWAT tactics, while others spoke on the widespread adoption of VR tech among recruitment aged demographics; "We need to stay in sync with generational expectations of what training evolution should be available. They use VR gaming and see applications for real training too."

Conclusions

The InVeris SURVIVR VR Law Enforcement Training System was evaluated in tandem with law enforcement agencies to determine the value of the system as a training tool. Through multiple

tests with officers and agents as test subjects, the TT&IC was able to gather feedback and determine the functionality of the InVeris SURVIVR VR Law Enforcement Training System.

Based on the observations and data collected, the following are the reporting results:

- The InVeris SURVIVR VR Law Enforcement Training System operates as advertised and provides training and applied practices in law enforcement de-escalation situations.
- The scenarios and tools enable the system to be used for policy and procedural instruction in other environments and situations that may be encountered by law enforcement personnel.
- Operator and technical issues were resolved by the InVeris technical team in a real time manner using the technical contact information provided with the system.
- Participant recommendations noted in this report and feedback provided to the manufacturer will improve the system's realism and training value.

Law enforcement officials indicated that the training system is useful in addition to classroom and live training curriculum. They also indicated the system provides a playback opportunity to show students what they did well, incorrectly or missed. Department leadership and participants noted the system could be used as a recruiting tool for potential recruits.

It should also be noted that technology included in the InVeris SURVIVR system is rapidly evolving and becoming more interactive and realistic. Virtual Reality continues to offer a safe, effective medium for training personnel in decision making and evaluating the use of proper policy, procedures and techniques in a safe and lower cost manner.

References

Chang, E., Kim, H. T., & Yoo, B. (2020). Virtual Reality Sickness: A Review of Causes and Measurements. *International Journal of Human–Computer Interaction*, *36*(17), 1658–1682. https://doi.org/10.1080/10447318.2020.1778351

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Appendix A: TEEX-Tested Test Plan for InVeris

Test Strategy:

The TT&IC assessment team will implement the scenarios to assess the operational capabilities of the InVeris SURVIVR Virtual Reality Training System in a realistic and safe environment. During these scenarios, multiple users, including members of the expert review panel and public safety professionals of various skill and experience levels will be asked to operate and provide feedback on the operational performance of the system based on their professional experience and knowledge. Data will be collected from the expert review panel and public safety personnel using written questionnaires provided at the beginning of the technology demonstration to all participants who sign the informed consent form and opt in to provide their feedback. The forms will be collected by the assessment team, scanned into an electronic PDF format, and then stored on a USB hard disk drive for later transcription. Once transcribed, the information will be aggregated for use in the final TEEX-Tested report. Additionally, the assessment team may facilitate small group discussions with the empaneled subject matter expert group and public safety professionals. The facilitated discussions will follow the questions on the questionnaire and include additional probing questions based on the context of the conversation. Field notes will be taken by the facilitators (assessment team), scanned, and used in the development of the final TEEX-Tested Report.

The assessment is conducted by experienced professionals using representative facilities and environments in which the InVeris SURVIVR Virtual Reality Training System is expected to operate. TEEX-Tested is a service line offered to customers on a contractual basis. The assessment is focused on the usability and operation of the software and external supplied gear for training. The assessment will be conducted by the TEEX staff. During this assessment, Central Texas Police Academy students will participate in it as part of their scheduled curriculum and additional free engagement time. Select certified Texas Peace Officers, other law enforcement representatives, and TEEX instructional designers' staff will also participate in demonstrations of the system. The assessment will be designed, coordinated, and analyzed by TT&IC staff.

Test Objectives:

The objectives of this assessment are:

- Assess the SURVIVR VR Training tool's quality of information provided by the developer for the end-user.
- Assess the amount of time needed to learn and understand the use of the SURVIVR VR Training tool.
- Assess the SURVIVR VR Training tool's scenario development capabilities and scenario fidelity.
- Assess the SURVIVR VR Training tool's performance as a virtual reality system.
- Assess the SURVIVR VR Training tool's performance as a law enforcement training tool.
- Assess the SURVIVR VR Training tool's performance as a law enforcement de-escalation decision-making development system.

Resources Needed:

- Complete 2 operator InVeris SURVIVR Virtual Reality System
- WIFI (optional)
- Multiple electrical outlets
- Min 10ft x 10ft space, Max 35ft x 35ft space

Assessment Staff:

- Ray Ivie – Director

- Michael Avolio – Technology Evaluation Manager

Quantitative Metrics:		Qualitative Metrics:		Metrics Other:	
Storage of system, shipping	X	Mix of scenarios provided	X	Safety of training environment	
Set up time, ease of set up	X	Ease of scenario creation	X	Assessed training in decision making	
Battery life for training	X	Immersion: Sense of presence and engagement with environment	X	Assessed value of scenarios vs available facilities	
Average Scenario length	X	Instructor Control, user interface	X	Assessed safety of virtual vs physical training	
Functionality of equipment	X	Realism: Realism of scenarios	X	Assessed savings in labor, travel, etc.	
Battery recharge	X			Assessed limitations in training	
Reliability	X			Skills, decision making	
Frame rate	X			Value of rarely seen scenarios, i.e. Low probability- high impact	
Resolution	X			Savings on wear/tear of equipment	
Start-up time	X				
Tracking accuracy/latency	X				
Average scenario length	X				
Control of avatars	X				
Durability	X				
System stability	X				
Cost of training	X				

- Jamila Powell – Administrative Assistant III
- Joshua Krueger – Graduate Student Worker
- Robert Mount – Graduate Student Worker

Test Environments:

- TEEX Testing and Innovation Center Workspace for 15' X 15' (225 sq ft) configuration
- Bush Combat Development Center high bay facility for 35' X 35 ' (1,225 sq ft) configuration
- Meeting room for debriefing

Schedule:

5/31 – InVeris Installation and Training by InVeris Representatives
6/15 – First assessment with the Texas Highway Patrol representatives **(T1)**
8/28 – College Station Police Department assessment **(T2)**
8/31 – TEEX Law Enforcement Academy assessment **(T3)**
9/1 – Bryan Police Department assessment **(T4)**
9/7 – Texas Alcoholic Beverage Commission (TABC) assessment **(T5)**
9/7 – Texas A&M University Police Department (UPD) assessment **(T6)**
9/8 – Bush Combat Development Center (BCDC) facility tour
10/18 – Equipment moved to BCDC
10/23 – Second assessment with the DPS at BCDC & conclusion of operational testing **(T7)**

Table 9 Table of Assessed Metrics

TEXAS A&M ENGINEERING

EXTENSION SERVICE