

**YEAR 2 ANNUAL
REPORT NARRATIVE**



**Soft Target Engineering
to Neutralize the
Threat Reality**

JULY 1, 2022 - JUNE 30, 2023

A DHS CENTER OF EXCELLENCE
Submitted by Northeastern University
August 31, 2023

Soft Target Engineering to Neutralize the Threat Reality



A Department of Homeland Security Center of Excellence

Year 2 Annual Report Narrative

July 1, 2022 - June 30, 2023

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Lead Partner: Northeastern University

Other Academic Partners: Boston University · Rensselaer Polytechnic Institute · Rutgers University · Tufts University · University at Buffalo, the State University of New York · University of Florida · University of Notre Dame · University of Puerto Rico at Mayagüez · University of Rhode Island · University of Southern California

Cover Photo: Dr. Dimitri Kusnezov, the Department of Homeland Security Under Secretary for the Science and Technology Directorate (USST) and SENTRY Director, Michael B. Silevitch, met with SENTRY students during the April 2023 USST Visit.



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DIRECTOR'S MESSAGE



Dear SENTRY Community - I am proud to present a snapshot of the accomplishments that our dedicated team of researchers, students, and partners have achieved at SENTRY over the past year.

We have been busy cultivating strong relationships with our fellow Department of Homeland Security (DHS) Centers of Excellence (COEs), colleagues, and key stakeholders including the Cybersecurity and Infrastructure Security Agency, Customs and Border Protection, and the Transportation Security Administration. SENTRY has been building a student leadership council, hosting research opportunities, and participating in events to foster collaboration and advance the achievement of our 10-year mission. Our Practitioner Advisory Board (PAB) continues to play a crucial role in offering advice and real-world examples based on their professional experiences that advance the direction of our case studies, while our Industry Partners actively contribute insights and feedback into ongoing initiatives, ensuring the alignment of our efforts with industry needs.

SENTRY announced the launch of its new website, sentry.northeastern.edu, to advance our ability to keep our broad community up to date on our activities and accomplishments. For example, there are links to the vision and mission of our Center along with descriptions of our research, case studies, industry partnership and workforce development activities.

Attendance by SENTRY leaders, researchers, and collaborators at networking events maintained and grew valuable relationships with industry and DHS stakeholders. Many of our researchers presented at conferences and workshops, communicating our progress to date and collecting valuable insights from peers to refine and expand our work. The individual project reports contain references to these important deliverables of our COE.

We've made significant progress with our first two case studies: School Security and Secure Surface Transportation by collaborating closely with venue stakeholders and members of our PAB. Findings from these studies will support our overarching goals of creating a Virtual Sentry Framework and providing stakeholders with informed decision-making capabilities when faced with threats to their soft target venues.

DIRECTOR'S MESSAGE



Our Workforce and Professional Development Program has been actively engaging with center students and researchers, Homeland Security Enterprise and DHS professionals, community college and minority serving institutions, as well as relevant industry, government, and community colleagues. These engagement efforts include workshops to introduce SENTRY-related topics to a wider audience, student design challenge events and research experiences for students that highlight the importance of real-world applications, and information sessions on techniques, tactics, and procedures to secure vulnerable venues, such as schools and surface transportation locations. Our mission extends beyond research, as we strive to raise awareness about SENTRY's purpose and promote diversity and inclusion throughout our initiatives. One key example is a supplemental program awarded to SENTRY starting July 2023 that links all the COEs to the NSF funded \$10 Million, five-year Engineering PLUS Alliance award where I serve as a Co-Principal Investigator.

In summary, I am invigorated by the collaborative spirit and innovative ideas that our partners and peers bring to the table. The material in this Annual Report provides a comprehensive overview of our accomplishments over the past year – propelling us towards our goal of better securing soft targets and crowded spaces. I look forward to us continuing this important journey together.



Michael B. Silevitch

Director, Soft Target Engineering to Neutralize the Threat Reality (SENTRY), a Department of Homeland Security Center of Excellence

YEAR 2 HIGHLIGHTS

July 1, 2022 - June 30, 2023



FUTURE OF SCHOOL SECURITY WORKING MEETING

SENTRY and the Pacific Northwest National Laboratory (PNNL) held a Future of School Security Working Group Meeting virtually on July 19 and 20, 2022. The meeting assembled school security stakeholders - including school administrators and security personnel, federal, state, and local government representatives, first responders, and industry technologists - to discuss how a Virtual Sentry Framework (VSF) can support safe, learning-conducive environments in schools. Results from the session are fueling research and development of the VSF.

TRANSPORTATION SECTOR SECURITY BRAINSTORM AND IDEATION SESSIONS

SENTRY hosted two virtual fact-finding sessions related to the secure transportation case study – a Transportation Sector Security Brainstorming Session that took place November 18, 2022, and a Transportation Ideation Session on April 18, 2023. These sessions facilitated open discussion between transportation sector security stakeholders and SENTRY personnel on how the VSF can best address security concerns for surface transportation venues. Key takeaways from the session will be used to shape the future development of the VSF.

SENTRY INDUSTRY ADVISORY BOARD MEETING

On November 29, 2022, SENTRY hosted its first annual Industry Advisory Board (IAB) meeting, held at the Northeastern University (NU) Innovation Center in Burlington, Massachusetts. Current and potential IAB members gathered with SENTRY leadership to discuss the benefits of partnering with SENTRY and to tour two SENTRY testbed facilities.

YEAR 2 HIGHLIGHTS

July 1, 2022 - June 30, 2023



ADSA26

SENTRY hosted the twenty-sixth Advanced Developments for Security Applications (ADSA26) workshop on November 30-December 1, 2022. A hybrid event, both in-person at NU in Boston, Massachusetts, and with a virtual component for remote participation, ADSA26 focused on “Reducing the Lethality of Attacks on Soft Targets” attracting over 150 participants from academia, industry, and government.

SENTRY BOARD OF DIRECTORS MEETING

On February 7, 2023, SENTRY held its inaugural meeting with our Board of Directors (BOD). The virtual forum enabled SENTRY to provide the BOD a thorough overview of our mission and work to date and to receive feedback on our direction and efforts.

DASSH STUDENT DESIGN CHALLENGE

Combining efforts with fellow DHS COE, the Center for Accelerating Organizational Efficiency (CAOE), SENTRY hosted its first DASSH (Designing Actionable Solutions for a Secure Homeland) Student Design Challenge from February 24-26, 2023, focusing on the theme of “Protecting America’s Public Access Areas.” Members of the SENTRY Practitioner Advisory Board (PAB) and SENTRY personnel participated as both mentors and judges for the event and one of the SENTRY student teams took a second-place prize for their solution.

SENTRY RETREAT

SENTRY leadership, researchers, workforce professional development (WPDP) personnel, and DHS Program Managers convened for a retreat in Washington, D.C. March 22-23, 2023. The focus of this meeting included defining the VSF, establishing goals and deliverables for SENTRY Year 4, Year 6, and Year 10, and refining the scope and priorities of the research and WPDP efforts. The takeaways will guide SENTRY’s strategy as we commence Year 3 and beyond.

YEAR 2 HIGHLIGHTS

July 1, 2022 - June 30, 2023



USST VISIT & STUDENT POSTER PRESENTATION NETWORKING SESSION

SENTRY was honored to host Dr. Dimitri Kusnezov, Department of Homeland Security (DHS) Under Secretary for the Science and Technology Directorate (USST), with SENTRY leadership, researchers, and students in-person at Northeastern University in Boston, Massachusetts on April 12, 2023. Highlights of the event included a Question-and-Answer session with Dr. Kusnezov and SENTRY students and a presentation by SENTRY's winning DASSH student team. The event was followed by a poster and networking session where SENTRY students presented their research and connected with SENTRY and DHS personnel.

RECONNECT WORKSHOP

SENTRY's Director and researchers joined 19 faculty participants at the Reconnect Workshop June 18-23, 2023 - including participants from community colleges and minority-serving institutions - in lectures and activities focused on risk assessment, working to foster broader participation of underrepresented groups in our mission.

SCHOOL & SURFACE TRANSPORTATION SITE VISITS

In February-June 2023, the SENTRY Case Study team collaborated with key school security and surface transportation stakeholders to hold several in-person site visits, including visits to Lincoln High School and Middle School in Lincoln, Rhode Island; Sandy Hook Elementary School in Newton, CT; the Houston Metro Authority; and the New Jersey Transit Authority. These visits allowed SENTRY to gather venue-specific information and refine the concept of the VSF as it pertains to these soft targets.

SENTRY WEBSITE LAUNCH

Our new website – sentry.northeastern.edu – launched in June 2023. As we continue our transformative research, we plan to use our new digital forum to connect community members and inform the public about our work.

YEAR 2 HIGHLIGHTS

July 1, 2022 - June 30, 2023



STUDENT & RESEARCHER ACCOMPLISHMENTS

SENTRY students and researchers were recognized for several awards and accomplishments in Year 2.

Dr. Jun Zhuang, Research Thrust C Lead and Project RC.2 PI, has been selected as a fellow of the Society of Risk Analysis (SRA), while Ian Unson, a PhD student working with Dr. Zhuang, received a Student Merit Award from the SRA.

Jared Miller, a PhD student turned postdoctoral researcher with Project RA.1, was awarded the Young Author Prize at Robust Control Design – 10th ROCOND 2022, as well as the Outstanding Student Paper Award at the 2022 IEEE Conference on Decision and Control.

Dr. Milad Siami, Project RA.1 PI, and his student lab team were awarded first place in the Self-Driving Car Competition at the American Control Conference (ACC) 2023.

Dr. Peter Ricci, a postdoctoral researcher with Project RB.1, received the University of Rhode Island (URI) Graduate School Outstanding Doctoral Research Award and URI Graduate Student Research and Scholarship Excellence Award in Life Sciences, Physical Sciences, and Engineering.

Dr. Jie Gong, Project RD.2 and Project RD.3 PI, was awarded the 2022 School of Engineering Outstanding Faculty Award at Rutgers University for his outstanding contribution to research, education, and services.



SENTRY YEAR 2 NARRATIVE

July 1, 2022 - June 30, 2023

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I. OVERVIEW

The Soft Target Engineering to Neutralize the Threat Reality (SENTRY) Department of Homeland Security (DHS) Center of Excellence (COE) addresses the challenges of protecting a wide range of soft targets and crowded places (STCPs). The scope of these challenges is vast: there are hundreds of thousands of STCPs in the U.S., accessed by tens of millions of people each day. Because of the volume and variability of STCPs, there are frequently limited security or protective measures and limited resources to enhance those measures. Three recent changes have augmented these challenges: a more diverse set of actors and motivations, communication advances that have compressed the timeline to detect and prevent violence, and greater access to a range of weapons. Compounding these technical challenges, STCPs frequently straddle the public-private domain, and there are insufficient Homeland Security (HS) professionals with the training needed to address these challenges as they presently exist and will evolve over time.

The **SENTRY vision (Figure I-1)** to address these challenges is the Virtual Sentry Framework (VSF), which we define as the real-time decision support systems enabling actionable situational awareness leading to more effective threat assessment, preparedness, mitigation, and response for STCPs. Versatile, scalable, and cost-effective, the VSF will function semi-autonomously with the capability to rapidly integrate and process data to provide real-time decision support to STCP decision makers (e.g., school principals or the heads of light rail operations) as they interact with first responders to detect, deter, and mitigate targeted violence. In support of this vision, the **SENTRY mission** is two-fold: (1) conduct **stakeholder-informed research** to better secure STCPs, and (2) to educate the current and future HS **workforce** in this space.

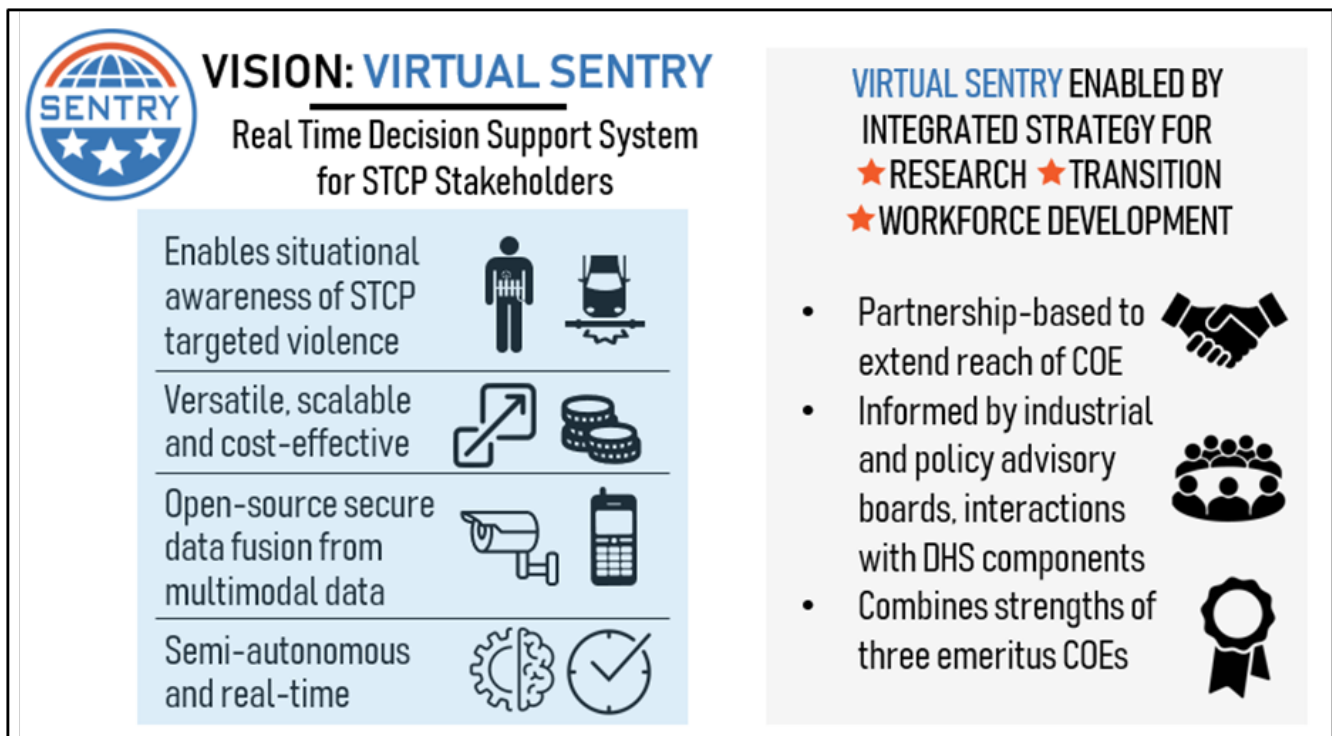


Figure I-1. Integrated SENTRY strategy for research, transition, and workforce development, anchored by the Virtual Sentry Framework (VSF). Open source enables external and in-kind contributions.

The SENTRY team combines the strengths of three emeritus DHS COEs: Awareness and Localization of Explosives-Related Threats (ALERT), Command, Control and Interoperability Center for Advanced Data Analytics (CCICADA), and Center for Risk and Economic Analysis of Threats and Emergencies (CREATE). ALERT, led by Northeastern University (NU), brings a strong track record of threat anomaly detection using advanced sensor technologies and signature analysis algorithms. CCICADA, led by Rutgers University, has pioneered in the protection of STCPs such as stadiums and surface transportation infrastructure. CREATE, led by the University of Southern California (USC), has developed optimal methods of assessing risks due to unanticipated attacks on soft target venues. All three emeritus COEs have produced meaningful transition to the field with significant impacts on workforce development and first responder training. Other SENTRY academic partners include Boston University (BU), University of Florida (UF), Rensselaer Polytechnic Institute (RPI), Tufts University, University of Notre Dame (ND), University of Puerto Rico-Mayaguez (UPRM), a **Minority-Serving Institution**, University of Rhode Island (URI), and the University at Buffalo, the State University of New York (UB). (Figure I-2).



Figure I-2: SENTRY academic partners, building on the strength of three emeritus COEs – ALERT, CCICADA and CREATE.

SENTRY has established partnerships well beyond academia as well, to both inform and transition SENTRY research and workforce development elements to stakeholder end-users: industry, national laboratories, operators of both public and private STCPs, and state and local governments.

Through the SENTRY-established Industry Advisory Board (IAB) and Practitioner Advisory Board (PAB) comprised of experts from the public and private security sectors, interactions with DHS Operational and Support Components, visits to STCPs, and SENTRY convening events like the highly successful ALERT Advanced Developments for Security Applications (ADSA) workshops, SENTRY leadership will pursue a continuous process of stakeholder need identification and response to address protection of STCPs.

Figure I-3 outlines the center’s feedback-driven research program and outlines the detailed organization, research and facilities needed to achieve the ten-year VSF. **Level 3 (L3)** shows the grand challenges that must be addressed to protect all STCPs. An analysis of the barriers associated with these grand challenges

leads to the fundamental research program at **Level 1 (L1)**. The research area entitled “Real Time Management of Threat Detection & Mitigation (RA)” is the heart of the VSF design orchestrating the real-time data management and decision support that will enable effective protection of the STCP venues. The other research areas at Level 1 (RB, RC and RD) support RA in the development of advanced sensing strategies, risk assessment and architectural designs.

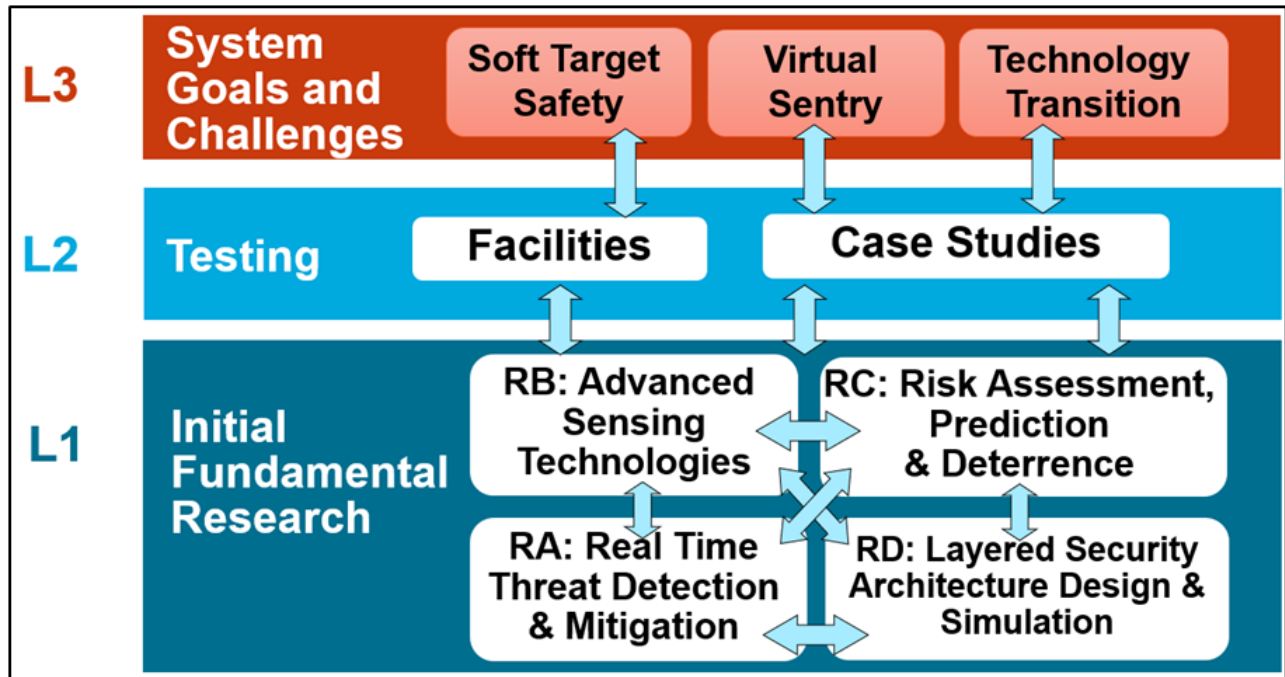


Figure I-3: The SENTRY research structure ties STCP technical challenges (Level 3) to fundamental research (Level 1) and identifies the facilities needed (Level 2) to test outcomes from Level 1 at scale before integrating them into the overall VS concept.

The ten projects that were identified for the initial SENTRY research program continued in Year 2. These projects will develop novel solutions for the foundational enabling elements of a VSF such as: development of new sensor concepts; application of artificial intelligence (AI)/machine learning (ML) to risk assessment, quantitative threat deterrence, development of layered security architectures; and providing methods for fusing data and other information.

Existing unique testbed facilities indicated in **Level 2** will enable testing and evaluation of Level 1 research outcomes for continuous improvement of the overall VSF over the ten-year period of the COE. These facilities include: Testbed TA: NU Expeditionary Cyber and Unmanned Aerial System (ECUAS) Lab Drone Offense & Defense Facilities, Testbed TB: NU Colosseum 5G/6G Agile Communications Facility, Testbed TC: Rutgers Living Lab Public Venues with Digital Twin, and Testbed TD: Guardian Centers Realistic Rail, Infrastructure Training Facility (**Figure I-4**). Use of these facilities will augment the research and pilot the development of the VSF. For example, The Colosseum and Agile Communications Facility (TB) will enable the incorporation of 5G/6G strategies to assess the robustness of first responder interoperability during a disaster, and the Guardian Centers Realistic Rail Infrastructure training facility (TD) will enable testing with realistic attack and defense scenarios. These testbed facilities will be utilized in subsequent years as the research is developed.

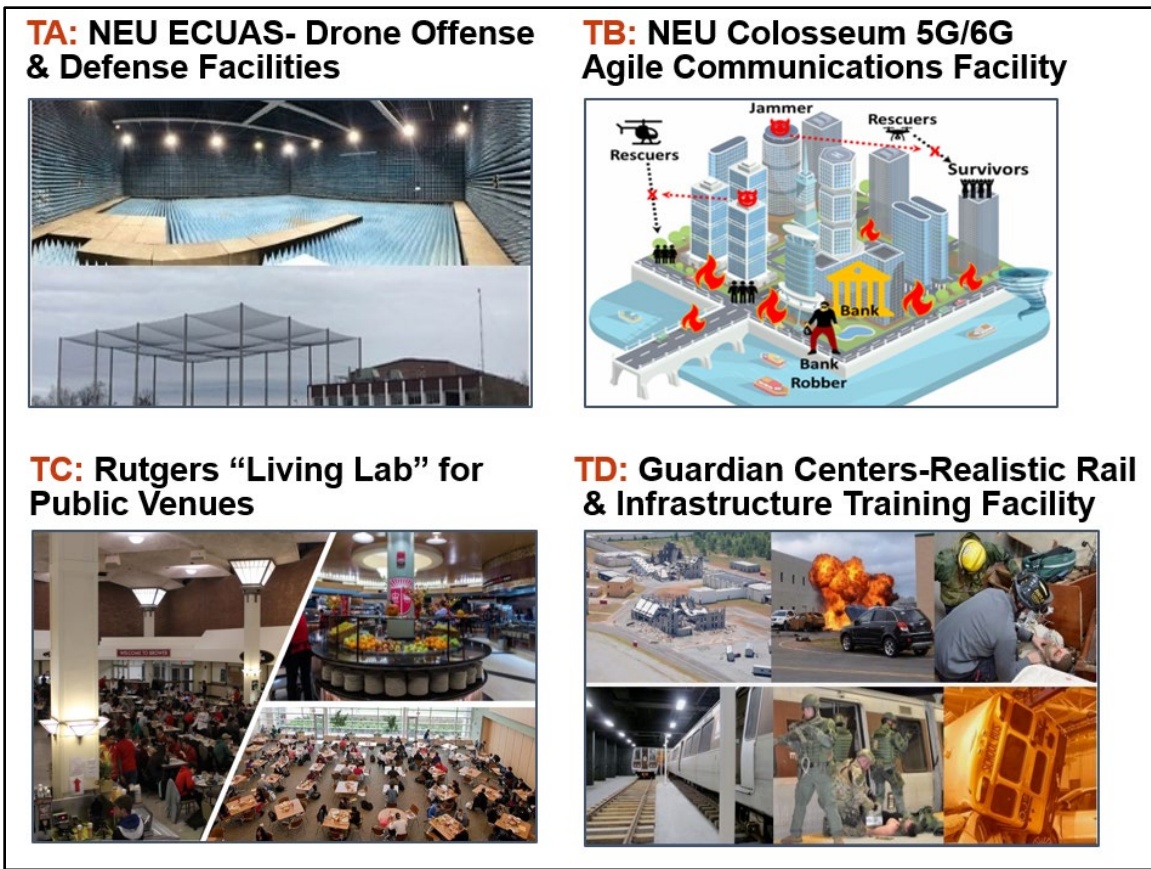


Figure I-4: SENTRY testbed facilities enable meaningful transition capabilities.

In addition to the test facilities, SENTRY created a strategy to embark on several case studies focused on specific STCP venues that will enable the various stages of the VSF design and implementation to be tested. Two types of case studies were initiated in Year 2: 1) School Security and 2) Secure Surface Transportation. In Years 3 and beyond, other venues such as stadium security, shopping malls, and places of worship will be studied. The connections and results engendered by the testing at Level 2 will provide a pathway to transition for public and private development of the VSF components.

This document contains the SENTRY Year 2 Annual Report for the 12-month period July 1, 2022, to June 30, 2023. It is based primarily upon the research and education projects which were provided in the original SENTRY proposal to DHS and the case studies that began this year.

II. RESEARCH PROGRAM

SENTRY's comprehensive research approach, outlined in **Figure I-3**, allows for continuous feedback between research outcomes and stakeholder needs and a pathway to transition for public and private development of the Virtual Sentry Framework (VSF). The goal of the SENTRY fundamental research program is to develop foundational results that can improve our ability to protect soft targets and crowded places (STCPs) at different levels. Proposed projects, organized into four research thrusts RA-RD (**Figure II-1**), approach this goal with techniques that work at multiple time scales, from design concepts for STCPs, to real-time information extraction and decision support systems for networks of advanced sensor concepts. In this section, we provide an overview of the four research thrusts and associated ten research projects, transition strategy, and case studies.

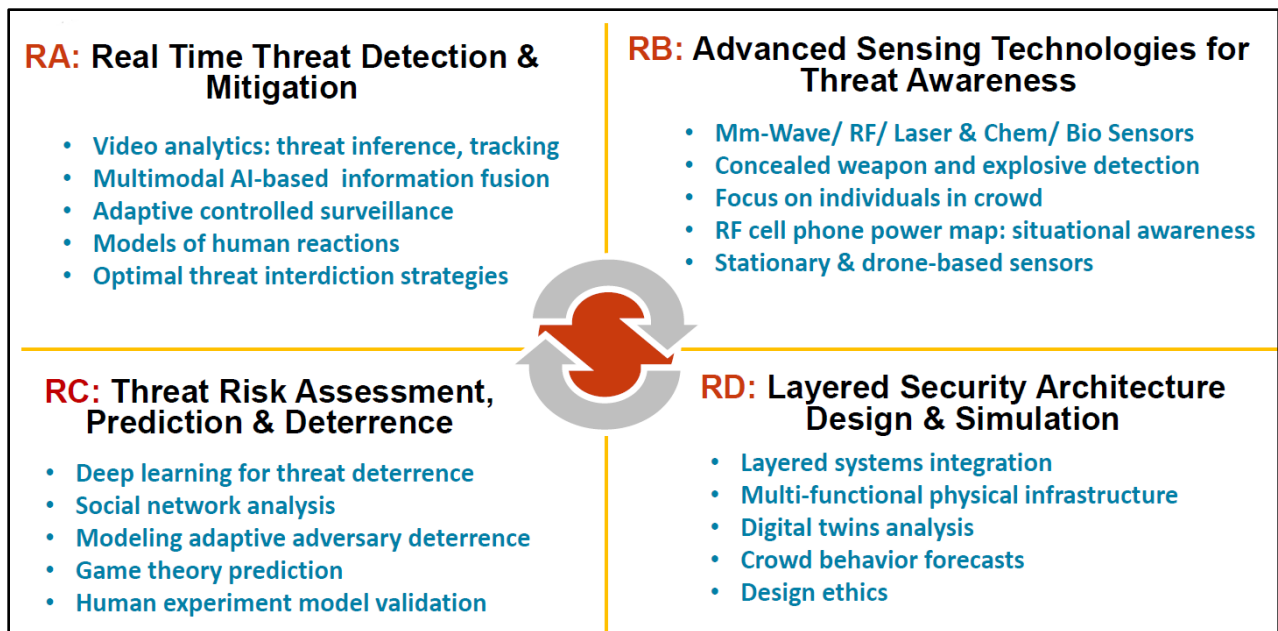


Figure II-1: The SENTRY Fundamental Research Program requires multidisciplinary discipline between the four research thrusts.

RESEARCH THRUST A (RA): REAL TIME THREAT DETECTION AND MITIGATION

RA is focused on developing algorithms for the protection of STCPs real time operations. The thrust consists of three main projects. Project RA.3: Real time Video Surveillance for Threat Detection and Mitigation seeks to develop methods to extract threat information from real-time networks of video cameras. The project has several areas of interest including detecting anomalous events in crowds, tracking suspicious individuals across networks of cameras, and classifying individual actions and behaviors to detect threats. Project RA.2: Low Complexity AI Based Fusion of Crowd-Sourced Heterogeneous Data Streams for Real-Time Threat Detection and Mitigation is focused on exploiting real-time information from personal devices such as cell phones and fusing information from diverse sources of data, in order to detect anomalous events of interest. Project RA.1: Real-time Management of Adaptive Surveillance and Mitigation seeks to develop decision support systems that assist decision makers in deployment and real-time control of layered surveillance systems and threat mitigation activities in response to dynamically evolving threat information. These decision support systems fuse the diverse sources of information, recommend tasking of additional sensors

to localize and confirm potential threats, and recommends alternative courses of action to mitigate the identified threats, taking into consideration human responses to the threats and to potential control directives.

In Year 2, the three projects have started developing models and initial algorithms that will form the basis for algorithm design and evaluation. Project RA.3 is using deep learning techniques for the video processing algorithms, which require significant training data. The team has set up data collections from publicly accessible webcams in stadia and large open areas. They have also explored the use of simulations as surrogate sources of data for training the algorithms. The team has developed initial algorithms for person tracking and action recognition, and has begun evaluations on public data sets. Project RA.2 has developed an agent-based simulation based on video game engines. This simulation will generate sample data from hand-held devices, and provide the foundation for developing learning algorithms to detect anomalies in crowds. Project RA.1 performed surveys of existing models for dynamic control of crowd evacuations and control of sensor networks that include the types of sensors that are being developed in Thrust RB and in industry. The team began development of algorithms for recommending sensor and crowd control actions in response to perceived threats. The team designed several experiments and data collections to develop models of human behavior in risky environments, and is waiting for the completion of CAPO review to conduct these experiments.

For more information, see the RA Annual Project Reports in Appendix A.

RESEARCH THRUST B (RB): ADVANCED SENSING TECHNOLOGIES FOR THREAT AWARENESS

In order to sense threats in the challenging crowd environment with cost-effective hardware, it is essential to employ the most advanced sensor concepts. RB seeks to complement workhorse networked video surveillance sensor technology by conceiving and developing sensing modalities that are not thwarted by layers of clothing that obscure threats. Further, we strive to extend the range of these sensing modalities to significant standoff distances to observe large portions of a crowd quickly, to avoid disrupting crowd movement, and to preserve a measure of anonymity. Two projects encompass four sensors: two chemical sensors, a radio frequency (RF) emission sensor and a millimeter-wave radar sensor. The chemical sensors, investigated in project RB.1: Multi-Sensor Threat Assessment Platforms, consider (i) high sensitivity Digital Dog Nose (DDN) thermodynamic sensors that distinguish different threat and non-threat vapors using a specialized set of catalysts; and (ii) Laser-Based Sensors (LaBS), using quantum cascade laser (QCL), and mid-infrared (MIR) laser spectroscopy, and a reflected light telescope, all aimed at identifying potentially threatening chemicals in a distant vapor plume. The electromagnetic sensors in project RB.2: Stationery and Aerial based RF/Radar Detection of Drones, Concealed Threats and Anomalous Communications investigate: (iii) Passive IR/EM Sensing (PIREM) for real-time situational awareness of crowds and crowd behavior using RF emissions from cell phones and other RF devices; and (iv) Active Electromagnetic (AEM) sensing using inexpensive fixed multi-beam radars coupled with video for tracking individuals who are concealing metallic objects that might be assault weapons, as they walk on city sidewalks and approach buildings.

Several new tasks have been incorporated into Year 2, including for the DDN: demonstrating the identification and differentiation of greater subsets of soft threats (i.e., gun oils, primers, and propellants) in the presence of interferents, measuring explosive vapors emanating from within luggage, and relaying sensor information to a command center in real time. Simulations have been completed and prototype high flow rate (>350 CFM) blowers have been fabricated. The LaBS sub-project is testing mid-infrared laser (QCL) spectroscopy characterization of acetone-water and $H_2O:H_2O_2$ mixtures: low limit of detection, limits of quantification, and high limits of detection; QCL characterization, and temperature-pressure dependence of toxic industrial compounds, chemical agent simulants, and bioterror simulants. Lab measurements are in progress for: Transmittance, Diffuse Reflectance, Absorbance, ATR, and Grazing Angle Reflectance sensing

modalities. The PIREM subproject demonstrated technical feasibility of cell phone emission localization and characterization using passive sensor networks measuring the power from emitters. RF sensing and mapping has been integrated with VIS/IR imaging of >12 nodes using a basic web-based interface. Initial designs have been developed for low-cost antenna systems to increase the resolution of emission localization, built upon the Notre Dame “Radio Hound” sensor platform system. The AEM radar sub-project continued developing extensive full-wave feasibility modeling, using the antenna design optimized in Year 1. Having concluded that the standoff backscattered response from even a large metallic weapon is comparable to that of a human torso, other more subtle scattering features must be identified and exploited. Simulation imaging shows one possible distinguishing feature is the nonuniformity of the reconstructed reflectivity spot. Another promising approach is applying artificial intelligence to decide the presence, position, and size of concealed attached metal objects. This requires many (~15,000) field computation simulations to train the neural network, and much thought must go into varying the body shapes and target characteristics. Subject motion is also being considered.

For more information, see the RB Annual Project Reports in Appendix A.

RESEARCH THRUST C (RC): RISK ASSESSMENT, PREDICTION, AND DETERRENCE

RC works at a faster time scale than RD (but slower than RB and RA), in which the architecture of the venues is already established; RC aims to assess risks and predict/deter potential threats to those venues. RC focuses on two projects, RC.1 and RC.2, each designed to assess risks and predict/deter potential threats to venues with existing and variable architectures and layers. Project RC.1: Machine Intelligence for Effective Threat Deterrence and Risk Mitigation at Soft Targets and Crowded Places seeks to develop artificial intelligence (AI) tools for data mining of social media, geospatial data platforms, and other sources of information to extract insights on potential threats and thus assist strategic and tactical security risk planning. The work focuses on explainable machine learning algorithms that will make the decisions accessible to users. Project RC.2: Protecting Soft Targets (ProSoT): A Game-theoretic Framework for Multi-target, Multi-layer Defense against Strategic Attackers is a complementary effort. It focuses on the problem of allocating resources to defend multiple potential STCPs, assuming that an intelligent enemy will be able to select STCPs that are easiest to attack and have the highest potential for negative impact. This work will offer insights and tools that can guide risk-informed security planning and security system design, particularly when venues can have multiple security layers.

In Year 2, RC researchers have made significant progress. In particular, RC.1 researchers have assembled the project team, set up the problem space, gathered initial data, and took. Moreover, preliminary steps towards developing solution frameworks and data-driven methods in machine learning, network science, and agent-based systems. In addition, RC.1 researchers have adapted and tested the machine learning-based approach called Graph Convolutional Networks (GCNs). Initially these were specifically tailored for urban rail networks, which generates node-level probabilities of adversarial targeting and assess the threat deterrence capabilities. RC.2 researchers have continued to build mathematical and simulation models for optimal resource allocation of countermeasures at soft targets to minimize the risks when faced with strategic and adaptive adversaries. These models were primarily developed through game theoretic solutions of attacker-defender games with the parameters primarily being shaped through literature review of related research and input from collaborating stakeholders. With CAPO approval, RC.2 researchers have also begun the collection of human subject research data which includes crowdsourcing responses to behavioral games and surveys on Prolific.

For more information, see the RC Annual Project Reports in Appendix A.

RESEARCH THRUST D (RD): LAYERED SECURITY ARCHITECTURAL DESIGN AND SIMULATION

RD is composed of three projects: RD.1: Architectural Design Research: Integrating Security in the Public Realm, RD.2: Dynamic Digital Twins for Secure and Smart Civic Space, and RD.3: Real-Time Crowd and Attacker Forecasting for Risk Assessment and Threat Mitigation. These three teams are focused on the interactions of crowds and the physical environment. Like design, this thrust is integrative by nature, that is, the work is focused on developing design tools, standards, and strategies for testing how all of SENTRY technologies can be deployed in real contexts and test their effectiveness through reliable simulations. As such, the efforts of RD in Year 1 and 2 have been very closely connected to the development of case studies, specifically the School Security Case Study and the Secure Surface Transportation Case Study. The RD.1 team has been involved in the brainstorming sessions and site visits with stakeholders in the school safety space. The RD.2 and RD.3 teams have been closely involved in the brainstorming and building of partnerships with the transportation safety stakeholders.

The first two years have been focused on literature review, human subjects research protocols and approvals, data collection, and testing of methods and approaches to integration. After achieving final IRB and CAPO approval, data collection has focused on three activities: (1) **defining the problem space**, specifically, RD.1 has conducted structured interviews with school designers and managers to understand current design practices for school security and identify knowledge gaps and design challenges for physical security and school climate; and RD.2 and RD.3 have engaged with stakeholder partners to understand the transportation security challenges and the potential utility of digital twins and crowd forecasting; (2) **developing and testing research methods**; specifically RD.1 developed a methodology to analyze official school shooting reports to identify physical and spatial factors in the vulnerability and response to mass shootings in schools, which is now being applied to transportation security incidents; RD.2 tested drone-based object detection and pixel geo-positioning, as well as methods to use video, IoT sensors, and AI to identify crowds and their behaviors; and RD.3 developed a multi-scale encoder framework for short term human trajectory prediction; and (3) **piloting the types of research and transition outputs**, specifically RD.1 is developing the first draft of graphic standards for the SENTRY visual design guidelines based on the spatial analysis of a sample of school floorplans, RD.2 has developed some initial digital twin models for a transportation terminal, and RD.3 is piloting a pipeline of Building Information Modeling (BIM) to simulation-ready scenes in collaboration with RD.2. The ongoing development a digital twin platform (RD.2) and models for crowd-building interaction and taxonomy of building spaces (RD.3) will support the SENTRY case study efforts by allowing the testing of design interventions (RD.1) and simulation of scenarios (RD.2 and RD.3) and eventually inform the architectural design guidelines to deploy SENTRY technology for specific venue types (RD.1). The three teams are interacting regularly to understand how the methods developed in one venue type will translate to the other.

For more information, see the RD Annual Project Reports in Appendix A.

RESEARCH TRANSITION

The SENTRY transition strategy includes regular, stage-gate-guided, metric-based project evaluations, market and competitive landscape analyses, project-transition partner matchmaking, and, as projects mature, yearly stakeholder driven SWOT analyses.

This year the SENTRY Transition Program focused on: 1) Continuing to facilitate the DHS CAPO review process; 2) directly engaging with SENTRY PIs and researchers on their milestones, deliverables, and reporting; 3) identifying and facilitating partnerships with other projects, security practitioners and end

users, government agencies and industrial partners; and 4) Standing up and managing two SENTRY Case Studies in School Security and Passenger-based Surface Transportation (further discussed in II. Research Program: Case Study Efforts).

Each SENTRY research project has a dedicated Transition Team Liaison who serves to provide both program management and transition support to the project PIs throughout the year. During Year 2, liaisons have facilitated industrial and venue partnerships, aided in the distribution of project deliverables to other SENTRY research teams and DHS components, and support in completing workplans and center reports.

CAPO Review

In the first 6 months of the year, the team packaged and submitted materials for 6 of the 10 SENTRY projects for CAPO review and answered questions or clarifications as requested by CAPO reviewers. Five of these projects, have been cleared to move forward with compliance-related work and one additional project (RA.1) is under active review.

Iterative Evaluation and Project Support

The technical maturity of projects is assessed on an annual basis using the DHS Product Realization Guide (PRG)[i] or updates thereof. These project evaluations, including site visits as warranted, are led and coordinated by the SENTRY Transition Team. Cyclical evaluations provide the Transition Team with an opportunity to develop stronger ties to SENTRY researchers and allow the team to identify areas which require transition support to benefit the advancement of the project and/or achieve milestones in a proactive way. These technical TRL assessments are supplemented with program management style assessments which occurred in concert with project reporting requirements (workplan development, semi-annual and annual reporting). These measures are critical in accounting for both the immediate resource, time and cost impacts of operational process improvements and the longer-term sustainment and maintenance impacts, providing a total, overall impact of a successful transition.

Project reviews were held during the first two weeks of December 2022. These reviews consisted of individual project meetings with the transition team and moderated by the project. The meetings focused on the progress of milestones and deliverables, transition support needed, review of project risks and budget spend downs. Action items were generated at these meetings for the project transition liaisons to follow up on; and a report on the discussions, transition team observations, and recommendations was developed in January 2023 and provided to the Center Director and DHS COE PM, Chelsea Thompson.

Facilitating Reporting Processes

To streamline the reporting process for PIs, the Transition Team partnered with the SENTRY Operations Team to develop a combined template for the semi-annual reporting cycle which incorporated both transition and program management updates.

To enhance the quality of SENTRY project reporting and milestone generation, in Spring of 2023, the Transition Team build a Transition 101 training module. This training module includes guidance on how transition is defined within the DHS COE space, the difference between research outputs and transition products, how to develop metrics-based and meaningful milestones, and clarity on Technology Readiness Levels (TRLs). This module is to be presented and recorded to SENTRY leadership and researchers on July 20, 2023.

Case Study Management

Understanding the needed core components for venue specific VSFs requires collaboration with multiple stakeholders including people presently responsible for public and private venue security. To facilitate this need, the SENTRY transition team has established venue-specific Case Studies defined in further detail in II. Research Program: Case Study Efforts. In the past year, members of the Transition Team have served as program managers for these case studies and have organized and led a series of structured events (listening sessions, ideation workshops, site visits) to help define those components. Leveraging the outputs of these events, the Transition Team have worked with Center Leadership and PIs to refine research milestones and deliverables, ensuring the research arm of the center is aligned with stakeholder needs and expectations.

CASE STUDY EFFORTS

SENTRY created a strategy to embark on several case studies focused on specific STCP venues that will enable the various stages of the VSF design and implementation to be tested. In Year 3, we continued work on two case studies, the first established in Year 1 focuses on school safety and the second, stood up in Year 2 focuses on securing passenger-based surface transportation. Future cases studies will explore other STCP venues such as large stadiums, places of worship, outdoor events, and retail facilities. The connections and results engendered by these studies will provide a pathway to transition for public and private development of the VSF components.

SENTRY has made substantial progress on the School Security Case Study as well as the Passenger-based Surface Transportation Security Case Study over the last year.

School Security Case Study

Future of School Security Working Meeting

On July 19 and 20, 2022 SENTRY and The Pacific Northwest National Laboratory (PNNL) held a virtual two-part, Future of School Security Working Group Meeting with the goal of envisioning how a VSF supports a safe, learning-conducive environment in schools five to ten years in the future. Attendees included first responders; representatives from federal, state, and local government; industry technologists; school administration, and security personnel. Aside from further expanding the community of stakeholders in this space who will engage with SENTRY, the workshop also resulted in a 77-page report consolidating the outputs of the event including what participants felt was needed and required to secure schools as well as initial concepts of a VSF. (Figure II-2).

This report was disseminated and reviewed by SENTRY Thrust Leads and researchers to help in their understanding of the school security domain and better inform SENTRY projects and the development of the VSF. This report was also provided to CISA's School Safety Task Force in support of their mission.

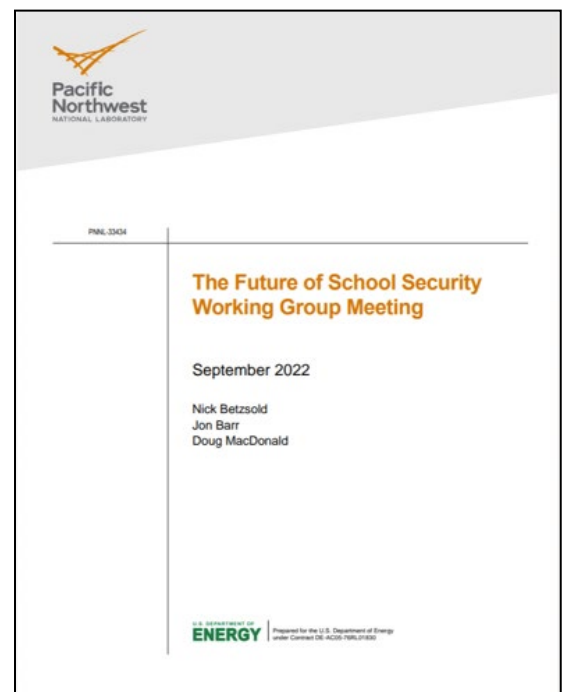


Figure II-2: Future of School Security Working Group Final Report

School Site Visits

Through our stakeholder engagement, we reached out to key school security stakeholders to plan and hold several in-person site visits to specific schools. These visits allow SENTRY to gather school-specific



Figure II-3: *Members of the SENTRY School Security Case Study team with Mark Pompano, Director of Security at Newton Public Schools, outside Sandy Hook Elementary School, Newtown, CT.*

information and refine the concept of the VSF as it pertains to schools. Three of these site visits took place this year, and we expect additional school visits in the coming year. Lawrence Filippelli, Superintendent of Lincoln Public Schools in Lincoln, Rhode Island facilitated visits to both Lincoln High School (March 10, 2023) and Lincoln Middle School (June 8, 2023). For both visits a team from SENTRY was able to observe a lockdown drill, tour the school and campus, and hold a school safety related discussion with school staff, administration, and Security Resource Officers (SROs).

Mark Pompano, Director of Security at Newtown Public Schools, facilitated our visit to Newtown, CT (April 4, 2023) (**Figure II-3**). Director Pompano afforded the SENTRY Team with an

opportunity to observe a city-run tabletop exercise focused on several school security scenarios. This event engaged both public and private Pre-K-12 Newtown Schools, school district administration, police, fire, and local emergency management. This event was followed by the SENTRY team being given a guided tour of Sandy Hook Elementary School in Newtown, Connecticut. Sandy Hook Elementary is a school that has undergone intensive security upgrades after the horrific shooting that claimed the lives of 20 children and six school employees in December 2012.

Additional School Engagement

In addition to our school site visits, we have fostered partnerships with other school systems this year. We have had several virtual meetings with Boston Public Schools, Boston, MA (March 6, 2023, April 25, 2023, June 23, 2023) (**Figure II-4**) and have begun the development of a Memorandum of Understanding to frame our work with the school district. Partnering with a large metropolitan district will lend diversity to the information we acquire on school security as their needs and requirements may vary greatly to a rural or suburban school system. On May 10, 2023 the School Security Case Study Team met with Brian Kempf, Director of School Safety and Security, of Elkhorn Public Schools(EPS) in Omaha, Nebraska. The meeting was an initial step in building a partnership with EPS, and we look forward to working with this school system over the next year.

We have also engaged with school security stakeholders through participation in events hosted by our partners in Lincoln, RI and through our WPDP efforts led by Prof. Jimmie Oxley which is further discussed in Section III: Workforce and Professional Development Program.

The partnerships with these school systems will directly impact and improve the research SENTRY executes within the school security space. Being able to work directly with school security experts and those responsible for the safety of students, faculty and staff will enable SENTRY to develop meaningful, relevant, and useful technologies within the space. We look forward to the continued partnership in support of our research and technology development.

Secure Surface Transportation Case Study

Transportation Sector Security Brainstorming Session

On November 18, 2022, SENTRY hosted a 3-hour Transportation Sector Security Brainstorming Session, held virtually via Zoom to facilitate open discussion between SENTRY personnel and transportation sector security stakeholders on how the VSF can best address security concerns for surface transportation venues. The invited transportation sector security panelists were:

- Vera Bumpers, Chief of Police, Houston Metro
- Ryan Fraser, Captain of OEM (Office of Emergency Management), New Jersey Transit
- Kevin Gaddis, Division Director for Surface Operations, TSA
- Polly Hanson, Senior Director of Security, Risk & Emergency Management, American Public Transportation Association
- Gina Osborn, Chief Safety Officer, LA Metro
- Ron Pavilik, Surface Operations Deputy Assistant Administrator, TSA
- Sonya Proctor, Assistant Administrator for Surface Transportation, TSA
- Chris Trucillo, Chief of Police, New Jersey Transit

SENTRY personnel included researchers, SENTRY leadership, Practitioner Advisory Board (PAB) members, and the SENTRY Program Manager. The meeting was recorded and transcribed to summarize key security challenges that the panelists are experiencing. In addition, SENTRY researchers and leadership provided feedback for internal use and will be used to advance further discussions and ultimately shape the development of the VSF.

Transportation Sector Security Ideation Session

Building on the information gathered from the Transportation Sector Security Brainstorming Session, and the feedback received from the SENTRY researchers, SENTRY organized a second invitation-only 2-hour



Figure II-4: Members of the SENTRY School Security Case Study team meeting virtually with school security stakeholders

brainstorming session on April 18, 2023 that included many of the panelists from the November 18th event. They were joined by SENTRY researchers and leadership, PAB members, SENTRY Board of Directors representatives, and Industry Advisory Board (IAB) members. The session was an open exchange of ideas and focused on exploring the inputs and outputs required to create a near-term and future decision support system that might address some of the key issues expressed by the panelists in the first session. The meeting was recorded and transcribed to summarize key outputs of the event for use by SENTRY leadership and research team.

Transportation Venue Site Visits

The SENTRY Transportation Sector Security Case Study team has engaged in two site visits to selected transportation venues to obtain briefings from stakeholders and end-users that will further inform the development of the VSF. The team's first visit was to Houston Metro Authority on February 23, 2023 and a visit to New Jersey Transit Authority(NJTA) on May 10, 2023.

The visit to Houston was led by Vera Bumpers, Chief of Police, Houston Metro and included a tour of the facilities as well as a discussion with Houston Metro security personnel. The visit to New Jersey Transit Authority involved members of the Surface Transportation Case Study Team and was supported by NJTA. The visit included tours of Penn Station, Hoboken Terminal and Secaucus Junction. Following this the team toured the emergency operations center in Maplewood. The day concluded with a discussion at NJTA headquarters.

The Surface Transportation Security Case Study Team will continue to search for opportunities to partner with transportation venues to test technology, processes, and procedures. Collaborating with the SENTRY IAB and PAB will become a priority for technology transition, testing and evaluating technology and procedures, and providing information on cutting edge technology and best practices within this space.

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III. WORKFORCE AND PROFESSIONAL DEVELOPMENT PROGRAM

The SENTRY **Workforce and Professional Development Program (WPDP)** identified the following five distinct projects in Year 1 which continued throughout Year 2: **WPDP-A:** Reconnect Workshop Series*; **WPDP-B:** Community College and Undergraduate SENTRY Instructional Modules*; **WPDP-C:** SENTRY Student Leadership Council Hackathon, **WPDP-D:** Internship/Co-op/Summer Research Experiences Pipeline, and **WPDP-E:** First Responder Workforce Development Training Series.

The WPDP projects were developed to engage key SENTRY stakeholders including center students and researchers, HSE and DHS professionals, community college (CC) and minority serving institutions (MSI), and relevant industry, government and community members. Projects WPDP-A and WPDP-B continued to build pipelines with CC and MSI faculty through content sharing and curriculum building activities to encourage a diverse population of students and educators to consider employment and study of HS-related science and engineering disciplines. To engage the SENTRY graduate and undergraduate students with HSE practitioners, we continued two projects with activities to encourage and facilitate such interaction, specifically: a) the student design challenge (project WPDP-C) hosted collaboratively with our sibling Center of Excellence, the Center for Accelerating Operational Efficiency (CAOE) and b) promotion of meaningful internship, co-op and research experiences at the SENTRY academic labs and testbeds, HSE and DHS operational areas, and relevant industry and state and local organizations (project WPDP-D). Project WPDP-E continued to provide educational opportunities for first responders and stakeholders from the case study venues.

WPDP-A: Reconnect Workshop Series



Figure III-1: WPDP-A Project Leader, Prof. Midge Cozzens (left) and SENTRY Director, Michael Silevitch (center) with other participants of Reconnect 2023.

Reconnect Workshops (RWs) are a vehicle to foster the broad participation of underrepresented groups at CCs and minority-serving institutions (MSIs) in the SENTRY effort to protect STCPs. Reconnect 2023 took place in June 2023 and focused on the topic of risk assessment with active participation in the weeklong lectures and activities from Director Michael Silevitch, and SENTRY Researchers Jun Zhuang and Auroop Ganguly. There were 19 faculty participants including six from CCs and three from MSIs (**Figure III-1**).

* WPDP-A and WPDP-B are interrelated projects with the workshops leading to the modules, so with the Year 2 Semi-Annual Report, we changed the project identifiers such that WPDP-A is the workshop project and WPDP-B is the module project. In past documents, the identifiers were swapped.

WPDP-B: Community College and Undergraduate SENTRY Instructional Modules

This project continues the work begun at the Reconnect Workshop to engage the RW participants in the development of SENTRY-related instructional modules with accompanying online professional development mini-courses. The CC/UG faculty participants who attended the June 2022 RW have submitted modules which will be posted on the SENTRY website in the fall of 2023. Through the modules, CC/UG students will learn foundational concepts in mathematical and computational sciences set in the context of issues relating to the security of STCPs, providing students with greater awareness of professional and academic possibilities.

WPDP-C: SENTRY Student Design Challenge

In Year 2, SENTRY began working with our sibling COE, the Center for Accelerating Organizational Efficiency (CAOE) to initiate an annual collaborative design challenge, known as DASSH (Designing Actionable Solutions for a Secure Homeland). Our inaugural event focused on problem statements related to Protecting America's Public Access Areas and took place on February 24 – 27, 2023 (**Figure III-2**). This student design challenge resulted in the participation by 23 student teams, including 2 teams representing SENTRY. It allowed for significant student engagement with DHS and HSE stakeholders beginning with the opening ceremony presentations, through the mentoring hours during the challenge weekend and ultimately, culminating with the presentation judging. The student participants benefitted from the opportunity to consider several real-world problem statements impacting homeland security and to work collaboratively to design, build and implement innovative solutions.



Figure III-2: DASSH – the first CAOE-SENTRY Student Design Challenge – took place February 24-27, 2023.

on problem statements related to Protecting America's Public Access Areas and took place on February 24 – 27, 2023 (**Figure III-2**). This student design challenge resulted in the participation by 23 student teams, including 2 teams representing SENTRY. It allowed for significant student engagement with DHS and HSE stakeholders beginning with the opening ceremony presentations, through the mentoring hours during the challenge weekend and ultimately, culminating with the presentation judging. The student participants benefitted from the opportunity to consider several real-world problem statements impacting homeland security and to work collaboratively to design, build and implement innovative solutions.

WPDP-D Internship/Co-op/Summer Research Experiences Pipeline

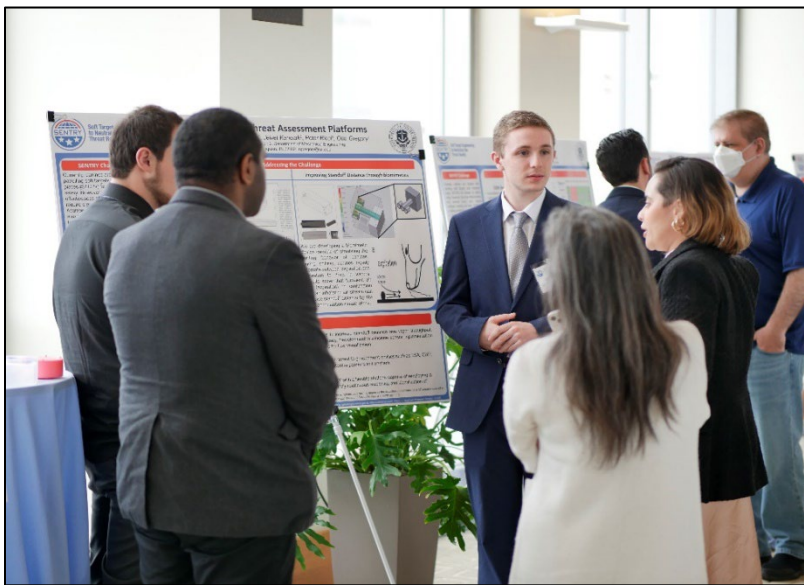


Figure III-3a: SENTRY students present posters on their current research at the SENTRY Student Poster Presentation and Networking Session held on April 12, 2023.

This project consists of two related sub-projects focused on providing opportunities for graduate and undergraduate students to find interesting and challenging positions related to the SENTRY research areas.

In Year 2, Dr. Samuel P. Hernández-Rivera of UPRM continued to host several students to participate in SENTRY-related research at UPRM. We also launched the SENTRY website in June of 2023 and are working to add a virtual bulletin board of opportunities as a resource for SENTRY student engagement in meaningful internship, co-op, and research experiences. The first SENTRY Student Leadership Council

(SLC) Meeting was held in January 2022 which led to the organization of student participation in the April 2023 the Department of Homeland Security Under Secretary for the Science and Technology Directorate Visit, which was followed by a Student Poster Presentation and Networking Session at which SENTRY students were able to present their work and connect with other SENTRY and DHS personnel (**Figure III-3a, Figure III-3b**). The SENTRY SLC conducted a survey in June of 2023 which they are using to propose logistics for future SENTRY student events, including the annual round table event where students, industry and government partners will network to publicize and plan for future opportunities and discuss successes and results of past opportunities.



Figure III-3b: SENTRY students present posters on their current research at the SENTRY Student Poster Presentation and Networking Session held on April 12, 2023.

WPDP-E First Responder Workforce Development Training Series

In Year 2, WPDP-E PI Jimmie Oxley held three meetings with first responders and stakeholders in the Lincoln RI school district, gave a presentation to the SENTRY Practitioner Advisory Board (PAB) and began joining the School Security Case Study meetings. The focus of the information provided through these events was on the active shooter problem. This focus will be expanded in Year 3.

For more information on each of the WPDP projects, see the WPDP Annual Project Reports in Appendix A.

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IV. MANAGEMENT, PARTNERSHIPS, AND ENGAGEMENT

In addition to the Research Program and Workforce and Professional Development Program (WPDP), SENTRY employs strategies related to management, partnerships, and engagements in order to achieve the department of Homeland Security (DHS) Center of Excellence’s (COE) mission.

MANAGEMENT AND EVALUATION

Leadership and Management Team

The SENTRY Organizational Structure, shown in **Figure IV-1**, has been designed to support the oversight, planning, and coordinating activities of this multi-faceted COE. The **SENTRY leadership and management team** includes experienced personnel with proven records of accomplishment, piloted by Michael Silevitch, SENTRY Director, and Carey Rappaport, SENTRY Deputy Director. SENTRY is led by an effective, experienced cross-campus team that will leverage a broader network of national advisors to ensure relevance of SENTRY activities. In addition to key leaders, experienced administrative and professional support staff are on hand to address the detailed needs of the COE.

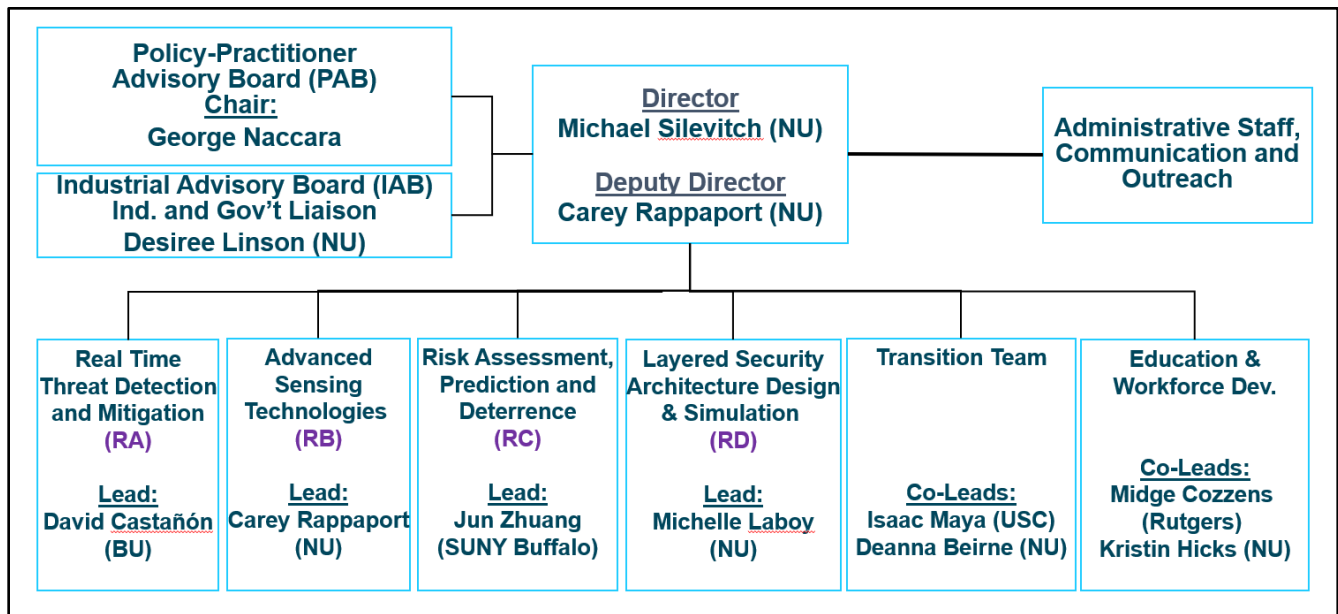


Figure IV-1: The SENTRY Organizational Structure for both the leadership and management of the COE as well as the interface with the SENTRY research, education and workforce development, and transition activities.

Executive Committee

The Executive Committee – which consists of the SENTRY Director, Deputy Director, Thrust Leads, Transition Lead and Workforce and Professional Development Program (WPDP) Lead – is responsible for coordinating, integrating and monitoring the progress and SENTRY research timelines, transition program, and workforce and professional development efforts.

Practitioner Advisory Board and Industry Advisory Board

The **Practitioner Advisory Board (PAB)** and **Industry Advisory Board (IAB)** guide SENTRY activities from complementary perspectives. Members of the PAB include world-class experts in the specific venues and challenges of STCPs and IAB representatives from leading commercial firms will help provide technology guidance toward the development of the VSF. Both PAB and IAB members participated in SENTRY events as appropriate. The IAB is comprised of industrial organizations who have committed participation in the center through membership fees or in-kind support. The SENTRY Industrial Liaison maintains continuous connection with this important group. For more information on the IAB, see IV. Management, Partnerships and Engagements: Industry and Government Partnerships.

The SENTRY PAB welcomed two new members in Year 2: Will Bernhjelm, Vice President of Security, Mall of America, and Linda Brown, Former Area Port Director, U.S. Customs and Border Protection (CBP), Boston, Massachusetts. Mr. Bernhjelm and Ms. Brown join a board of world-class experts in the specific challenges of STCPs and provide valuable insight and guidance in achieving SENTRY’s mission. The current composition of the SENTRY PAB is shown in **Figure IV-2**.

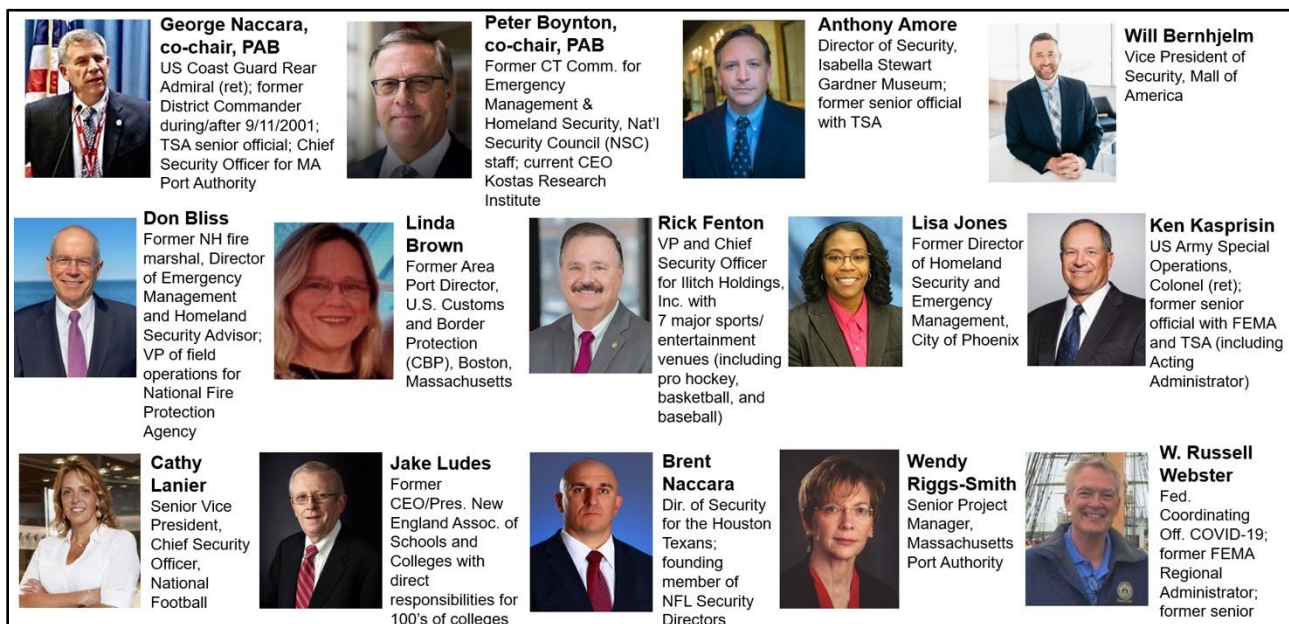


Figure IV-2: The SENTRY Practitioner Advisory Board (PAB) is composed of world-class experts in the specific challenges of STCPs.

The SENTRY PAB convenes monthly to engage the SENTRY leadership, management and research teams and provide insight and direction for the Center. In Year 2, the SENTRY PAB have been briefed on several research, WPDP, and case study initiatives, including: a) school safety and security initiatives in Rhode Island with Dr. Larry Filippelli, Superintendent, Lincoln Public Schools, Lincoln, RI and President/Proprietor, The Education Consortium; b) research overviews and objectives of SENTRY Research Strategy Thrust B and other SENTRY research and WPDP efforts; c) mission and research of the Center for Advanced Data Analysis (CCICADA) DHS Emeritus Center of Excellence; d) plans for the CAOES-SENTRY DASSH Design Challenge; and e) opportunities for collaboration with SENTRY IAB member MatrixSpace.

PAB member Jake Ludes, Former CEO/President, New England Association of Schools and Colleges, has been particularly involved in the School Security Case Study, advising SENTRY’s efforts in planning and running

the School Security Brainstorming Session and Future of School Security Working Meeting as well as providing contact with key school security stakeholders for site visits and other collaboration. Other members have provided feedback on the SENTRY proposal as well as presentations from SENTRY researchers. PAB members have participated in ADSA Workshops as both presenters and attendees, and many PAB members also participated as mentors or judges in the CAO-SENTRY DASSH Student Design Challenge that took place February 24 – 26, 2023.

Professional Support Team

In Year 2, SENTRY brought on four new personnel to fill essential staff positions: a) Akari Dollard, Technical Program Manager, b) Kevin Dang, Systems Coordinator, c) Rachel Rufo, Associate Director of Marketing and Communications; and d) Jess Fleming, Administrative Assistant. These individuals join our efficient and experienced professional support team, detailed in **Table IV-1**, in carrying out key administrative functions critical to running a successful COE.

Name	Area of Responsibility
Deanna Beirne	IT & Transition
Kristin Hicks	Workforce & Professional Development; Program Operations
Anne Magrath	Finance & Contracts
Kevin Dang	Systems Coordination
Akari Dollard	Technical Program Management
Jess Fleming	Administrative Assistance
Tiffany Lam	Events & Operations
Desiree Linson	Industrial & Government Partnerships
Makenna Lorange	Data & Reporting
Rachel Rufo	Marketing & Communications

Table IV-1: SENTRY Professional Support Team and responsibilities

Website Launch

SENTRY launched our new website in June 2023 (**Figure IV-3**). This resource has significantly enhanced efforts to share our mission and research related to the protection of soft targets and crowded places. As we continue our transformative research, we plan to use our new digital forum to connect with key stakeholders and inform the public about our work. For more information, see sentry.northeastern.edu.

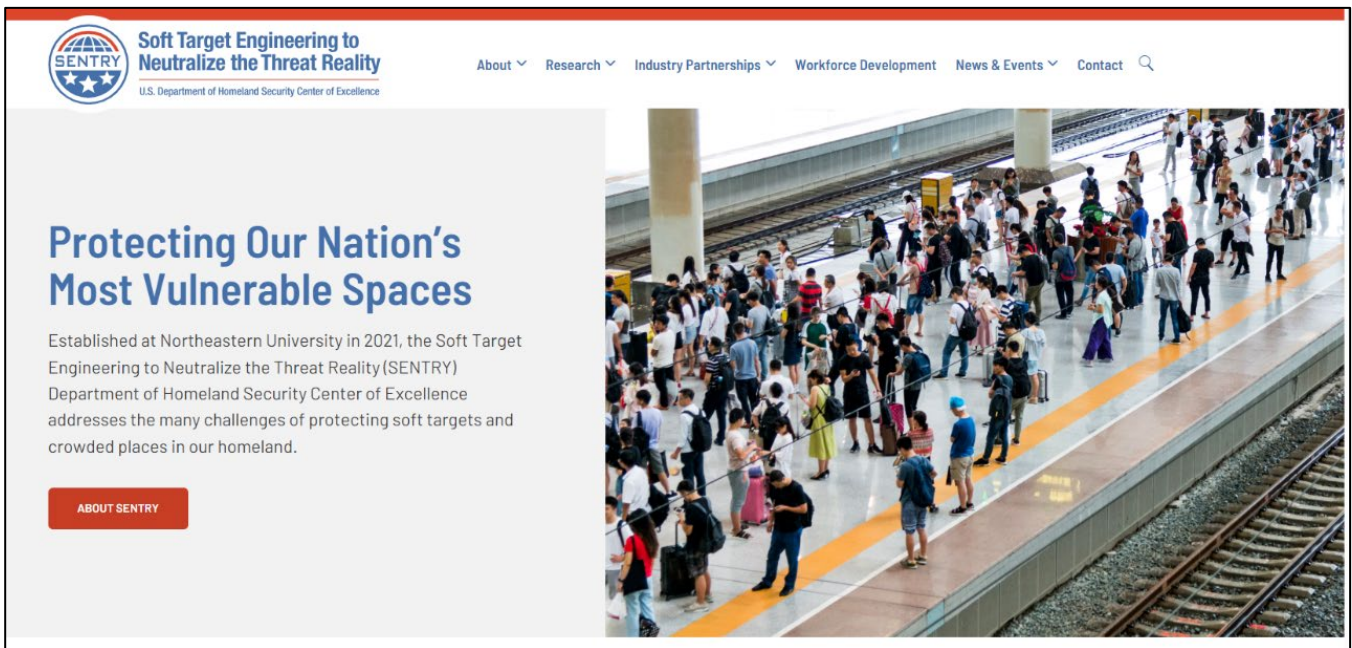


Figure IV-3: SENTRY’s new website – sentry.northeastern.edu – allows our COE to connect with others and share our work as we continue in our mission to protect soft targets and crowded spaces.

Evaluation

Strategic Evaluation Plan

To effectively accomplish the goals related to research, transition, education and workforce development outcomes, the SENTRY leadership has developed a **strategic evaluation plan** that can assess performance at both the project level and the program level. Effectively managing and evaluating the outcomes of this complex enterprise presents a challenge nearly equal to the basic research challenges themselves. To support this effort, the SENTRY leadership understands that each functional area within the Center must maintain its own unique charter, while considering evaluation methods that will have the necessary rigor, transparency, and credibility to provide a relevant and useful assessment of progress towards and accountability for desired outcomes. SENTRY's overarching Strategic Plan based on the three-level structure shown on **Figure I-3**, the SENTRY leadership team will be actively engaged in the ongoing assessment of research, transition efforts, and workforce and professional development (WPD) for both existing and potential new partnerships.

SENTRY Retreat

In March of 2023, SENTRY held its first center retreat (**Figure IV-4**). The goals of the retreat were identified as 1) finalizing the definition, goals, and scope of the Virtual Sentry Framework (VSF), 2) evaluate the current SENTRY portfolio and identify gaps, and 3) develop a SENTRY roadmap.

The retreat was attended by SENTRY researchers, leadership, and staff both in person at Northeastern University's Arlington, VA campus and virtually. During the second half of day two, the SENTRY DHS S&T Program Management Team joined to be briefed on the retreat outputs and answer questions identified during the retreat. Retreat outputs included the generation goals for the WPDP effort, a final definition of the VSF, topics for the SENTRY 2023 Request for Proposals, refined Case Study topics and prioritization list, and lastly an initial research and WPDP roadmap with key deliverables for Years 4, 6 and 10. On the research side, Year 6 will attempt to produce novel methods to provide core functionality of the VSF. Year 10 will attempt to deliver an integrated and tested VSF of venue-specific systems to the Homeland Security Enterprise (HSE). During this event it was determined there was a need for a research specific retreat which is scheduled for the end of September 2023.



Figure IV-4: SENTRY leadership and researchers convened for the first SENTRY COE Retreat March 2023 in Washington, D.C.

INDUSTRY AND GOVERNMENT PARTNERSHIPS

Creating collaborative research partnerships with industry and government entities is critical in developing and transitioning technology to stakeholders within the Homeland Security Enterprise (HSE) and advancing the research mission of SENTRY.

In establishing partnerships, SENTRY has leveraged previously existing collaborative partners forged by ALERT and Northeastern's National Science Foundation (NSF)-funded Engineering Research Center, Gordon-CenSSIS, as well as garnered new partners to its IAB.

Industry Partners sign a Partnership Agreement and provide membership donations that augment the core funds provided by DHS. Industry Partners engage with SENTRY by providing opportunities for researchers and students to work at their facilities, as well as providing access to research and development (R&D) leaders, real system-level applications, state-of-the-art hardware and software, willing partners for technology transfer, and collaborative partners for additional funding proposals and sustainability. Conversely, SENTRY provides its Industry Partners with access to talented professors, post-doctoral, graduate, and undergraduate students, and innovative research. Together, the industry/practitioner, government, and academic collaboration has been – and will continue to be – a powerful vehicle for advanced development. The current list of SENTRY IAB members, as of June 2023, is found in **Figure IV-5**. In addition to the IAB, SENTRY has a partnership with Pacific Northwest National Laboratory (PNNL) and works closely with the Cybersecurity & Infrastructure Security Agency (CISA): School Safety Task Force.



Figure IV-5: SENTRY Industry Advisory Board (IAB) members provide opportunities for advanced research and development.

SENTRY hosted its first annual IAB meeting on November 29, 2022 at the Northeastern University (NU) Innovation Center in Burlington, Massachusetts. Current and potential IAB members met with SENTRY leadership and management personnel to, among other activities, tour the NU ECUAS Lab Drone Offense & Defense Facilities and Colosseum 5G/6G Agile Communications Facility (Testbeds TA and TB).

The five-hour meeting also highlighted the benefits of partnering with SENTRY, which include: a) access to IAB members-only events: ASPIRE (Annual Student Pipeline Industry Roundtable), Industrial Advisory

Board Meeting, Annual Project Review, and Technology Demonstrations; b) fees waived for ALERT/SENTRY workshops: Advanced Development of Security Applications (ADSA), and Advanced Developments Encompassing Processes and Technology (ADEPT); c) access to SENTRY testbed facilities; d) transition opportunities: joint proposals and subcontracts for Task Orders under Basic Ordering Agreements; e) access to SENTRY researchers; f) use of ALERT datasets; and g) networking opportunities with DHS components, other federal agencies and labs, and other Industry Partners.

In Year 2, Industry Partners engaged with SENTRY in several new way: a) Industry Partners NEC and Matrixspace provided presentations to SENTRY stakeholders, researchers, and PAB members; b) Industry Partners participated in the Surface Transportation Security Case Study Ideation Session in which representatives from TSA, transit system authorities, and other transportation subject matter experts were panelists. During the session, panelists provided information on their challenges and described their current security postures. Industry Partners questioned the panelists and provided feedback on the session; c) Industry Partners were invited participants during the DHS S&T Undersecretary visit to SENTRY at Northeastern University, and they provided feedback following the visit; and d) Industry Partners began actively reaching out to SENTRY researchers to schedule in-depth presentations explaining their research projects.

Cambridge Consultants is the newest SENTRY IAB Partner, joining in early 2023. It has a global team of engineers, scientists, designers, and consultants who may assist SENTRY in product transition to stakeholders. The Industry Liaison will continue to strategically invite relevant industry to become members of the IAB.

SENTRY will continue to find opportunities for Industry Partners to actively engage with SENTRY in case studies, presentations, site visits to soft-target venues, and collaborating in SENTRY research.

STRATEGIC WORKSHOPS AND EVENTS

SENTRY Workshops are a key element of its ability to adapt its research program over the 10-year timeframe of the Center. Indeed, part of the Center of Excellence (COE) mandate from DHS is to develop, implement and disseminate its strategy to enable the achievement of the Center’s grand challenges. To support this effort, SENTRY continues to host an ALERT-initiated workshop series known as **Advanced Developments for Security Applications (ADSA)**. The outcomes of each workshop are documented in a report articulating a recommended roadmap of prioritized areas of long-range fundamental research. In addition, SENTRY hosts **other events** that support the mission and work of SENTRY, including special events related to specific case studies or engaging our industrial partners.

In Year 2, SENTRY hosted the twenty-sixth Advanced Developments for Security Applications (**ADSA26**) workshop on November 30-December 1, 2022, which addressed the theme “Reducing the Lethality of Attacks on Soft Targets” (**Figure IV-6**). This hybrid event was hosted at Northeastern University in Boston, Massachusetts, as well as virtually on



Figure IV-6: Participants engage with a presenter at ADSA26, which addressed the theme “Reducing the Lethality of Attacks on Soft Targets.”

Zoom, allowing participants from academia, industry and government to gather and network in-person while maintaining an option for remote participation. During the two-day workshop, 154 participants convened with subject matter experts and leaders to discuss detecting people with malicious intent and their weapons, hardening venues, rapid response to events, virtual sentires (command and control centers), and emerging technologies.

SENTRY virtually convened its **Board of Directors (BOD)** for the first time on February 7, 2023. The meeting included presentations on SENTRY vision and mission, research and workforce and professional development projects, case study efforts, and transition activities. As this was the first official meeting with the BOD, the primary goal was to provide a thorough overview of SENTRY to this advisory team while establishing a communication channel with the board allowing for continued future updates throughout the year.



Figure IV-7: SENTRY hosted a visit with the DHS USST in April 2023, which was attended by SENTRY researchers, students, and DHS personnel.

On April 12, Dr. Dimitri Kusnezov, the **Department of Homeland Security Under Secretary for the Science and Technology Directorate (USST)**, visited Northeastern University to meet with the SENTRY team to learn more about the work of SENTRY and its impact (**Figure IV-7**). The day kicked off with opening remarks from SENTRY DHS Program Manager, David Canty, and SENTRY Director, Michael Silevitch. Northeastern University President, Joseph Aoun, Vice Provost David Madigan, and Northeastern’s College of Engineering Dean, Gregory Abowd were in attendance to welcome Dr. Kusnezov and his team to Northeastern. Over 70 SENTRY researchers, students, industry partners, and PAB members attended the visit. Students and researchers had the opportunity to talk with Dr. Kusnezov in a one-hour roundtable session moderated by Dr. Silevitch. Dr. Kusnezov spoke to his career path, the challenges he has faced, and his direct experiences in the homeland security space. He also provided insight on his vision for the Science and Technology Directorate within DHS. The USST Visit was immediately followed by a **Student**



Figure IV-8: The SENTRY USST Visit was followed by a Student Poster Presentation and Networking Session, in which SENTRY student researchers had the opportunity to share their research and connect with DHS and other SENTRY personnel.

Poster Presentation and Networking Session (Figure IV-8). SENTRY students had the opportunity to present posters on their current research efforts and connect with DHS and other SENTRY personnel.

SENTRY also hosted the following events in Year 2, which have already been discussed in more detail within other sections of this report:

- Future of School Security Working Meeting (see page 22)
- Transportation Sector Security Brainstorm Session and Ideation Session (see page 24)
- Industrial Advisory Board Meeting (see page 35)
- School Security & Secure Surface Transportation Case Study Site Visits (see page 23 and page 25)
- DASSH Student Design Challenge (see page 28)
- SENTRY Retreat (see page 34)
- Reconnect Workshop (see page 27)

V. OTHER PROGRAM REQUIREMENTS

Requirements for the SENTRY Data Acquisition and Management Plan (DAMP), Information Protection Plan (IPP), and Research Safety Plan (RSP) are defined in Article I. A.10 (DAMP), 11 (IPP), and 15 (RSP) of the Center of Excellence (COE) Cooperative Agreement Terms and Conditions of the Financial Assistance Division (GFAD) provided to SENTRY dated January 24, 2022.

DATA ACQUISITION AND MANAGEMENT PLAN

Aligning with Northeastern University's (NU's) Office of Information Security, SENTRY has carefully formulated distinct data management policies according to artifact types, regulatory compliance and information management strategies, found within the SENTRY DAMP. NU provides data stewardship support through SENTRY's Senior Director of Technical Program Development and Strategy, while the Senior Director assumes the primary role as overseer of the development and management of the research data lifecycle.

In accordance with the DAMP, in Year 2, each SENTRY research project submitted a project-specific Data Management Plan (DMP), which was reviewed by the SENTRY leadership team to ensure that all SENTRY data is properly managed.

For more information, see the DAMP in Appendix C.

INFORMATION PROTECTION PLAN

In accordance with the SENTRY IPP, SENTRY worked with Research Compliance at Northeastern University to develop sensitive information training for SENTRY leadership and researchers. This training defines Sensitive Information (SI) and Classified Information (CI) types as defined in the SENTRY cooperative agreement, addresses how to handle and protect SI and CI if it is generated or obtained intentionally or accidentally, and the process for notification to SENTRY leadership if there is a concern that these types of information is generated or obtained. The training was made available February 2023 and was subsequently completed by the SENTRY Thrust Leaders; SENTRY Principal Investigators and research staff then completed the training in June 2023. This SI training will be repeated annually to ensure that SENTRY participants are informed on how to comply with SENTRY's IPP.

SENTRY Thrust Leads will meet at the beginning of Year 3 with the SENTRY Director to determine which research projects have the propensity to generate SI and/or CI and institute additional reviews of all publications and presentations as generated to ensure that SI and CI is not generated.

For more information, see the IPP in Appendix D.

RESEARCH SAFETY PLAN

The SENTRY Research Safety Plan (RSP) requires all SENTRY researchers submit a Laboratory Safety Plan (LSP), which will then be reviewed by the SENTRY Research Safety Board (RSB) to ensure that all SENTRY research meets the highest safety standards possible. Each SENTRY researcher submitted their LSP fall 2022, and the first annual SENTRY RSB Meeting took place November 28, 2022. Upon their review, the RSB did not recommend any changes or updates to the SENTRY RSP, and thus SENTRY will continue utilizing the RSP as is for the upcoming year. The RSB also reviewed the three LSPs that identified hazards and do not

recommend any additional lab safety protocols than those already identified by the researcher and/or required by the researcher's institution.

For more information, see the RSP in Appendix E.

BUDGET INFORMATION

The approved budget for SENTRY Year 2 is detailed in the cover page of the Center of Excellence (COE) Cooperative Agreement Terms and Conditions of the Financial Assistance Division (GFAD) provided to SENTRY dated January 24, 2022. Budgetary information for each research and WPDP project is detailed in Appendix A and breakdown of funding by budget category is found in Appendix F, but this information has been redacted for public dissemination in this abridged report.

VI. CONCLUSION

The SENTRY Department of Homeland Security (DHS) Center of Excellence (COE) has established a strong strategic base, supported by a meaningful vision and a mission that integrates research and education. In Year 2, SENTRY continued progress on its ten initial research projects outlined in the Research Program and five initial Workforce and Professional Development Program (WPDP) projects. SENTRY also strategically augmented its research portfolio with the introduction and incorporation of case studies, focusing on school security and secure surface transportation. These efforts will enable our COE to move concretely toward the design and implementation of the Virtual Sentry Framework (VSF).

SENTRY continued to be led by an effective, experienced cross-campus team that managed all components necessary to achieve our COE's mission, including transition efforts and regular program and project evaluation, as seen through our collaborative SENTRY Retreat which helped refine the vision and goals of our COE, and our first Board of Directors meeting. The SENTRY Practitioner Advisory Board (PAB) continued to be an active component of SENTRY and provided strategic guidance toward the definition and implementation of the case studies. New SENTRY Industry Advisory Board (IAB) members were recruited, and all IAB members have been engaged in SENTRY efforts through the IAB Meeting and other SENTRY events.

SENTRY had the great opportunity of hosting Dr. Dimitri Kusnezov, the Department of Homeland Security Under Secretary for the Science and Technology Directorate (USST), to an in-person visit to discuss SENTRY research and connect with students that was immediately followed by a student a poster and networking session. Students were also engaged with the CAO-E-SENTRY DASSH Student Design Challenge. SENTRY joined the ALERT Emeritus DHS COE in hosting the ADSA workshop series, creating collaborative opportunities by engaging participants from industry, national labs, vendors, government, and academia. SENTRY also hosted other events related to the case studies, including brainstorming sessions, working meetings, and site visits.

The SENTRY Research Safety Plan (RSP), Information Protection Plan (IPP), and Data Acquisition and Management Plan (DAMP) that were established in Year 1 have again been implemented as we are continuing to meet programmatic requirements of our COE.

SENTRY leadership has developed a firm base from which it can quickly adapt to encompass new research and education priorities to address DHS needs. Beyond Year 2 and using the Basic Ordering Agreement vehicle, SENTRY will move forward with its dynamically evolving three-level strategy to advance the state-of-the-art in homeland security technologies. The SENTRY team is proud to be able to help DHS meet the demands of its daunting mission of protecting soft targets and crowded places (STCPs).