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TO: The Subcommittee on Research and Technology and the Subcommittee on Investigations and Oversight, Committee on Science, Space, and Technology, U.S. House of Representatives

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SUBJECT: Prepared Testimony for the Congressional Hearing on *The Role of Technology in Countering Trafficking in Persons*

INTRODUCTION

Chairwoman Stevens, Ranking Member Baird, Chairman Foster, Ranking Member Norman, and members of the Subcommittees, thank you for the honor and privilege of submitting this written statement and joining you today to represent the Massachusetts Institute of Technology (MIT) Lincoln Laboratory and discuss with you some of our research on the role of technology in countering human trafficking.

MIT Lincoln Laboratory is a non-profit Federally Funded Research and Development Center (FFRDC) that researches and develops a broad array of advanced technologies to meet critical United States (U.S.) national security needs. The Laboratory's technology for national security mission is accomplished through three overarching lines of effort: quantitative systems analysis, rapid technology prototyping, and long-term technology development. One of our core areas of research involves developing technologies for global humanitarian assistance and disaster relief, and as part of that initiative we are building novel technologies and systems to counter human trafficking. In this testimony, I am pleased to highlight some our efforts to combat this complex and pervasive challenge.

First, we are leveraging modern advances in data science, machine learning, and related fields to develop enhanced digital evidence analysis capabilities to reduce the time- and human-intensive nature of human trafficking investigations and prosecutions. These capabilities are built on open-source advances in image recognition, automatic speech recognition, cross-language machine translation, and natural-language processing, and are honed through operational collaborations with

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investigators and prosecutors at the Department of Homeland Security (DHS), the Federal Bureau of Investigation (FBI), the Department of Justice (DOJ), and other state-level agencies. Second, we have performed a systems analysis of the human trafficking domain and developed the *Human Trafficking Technology Roadmap* for the DHS Science and Technology (S&T) directorate [1–3]. The roadmap consists of twenty-nine targeted findings and recommendations sequenced into a prioritized and phased implementation strategy, and informed DHS’s first published strategy to combat human trafficking earlier this year [4]. Lastly, we are planning a first-of-its-kind workshop focused on technology for counter human trafficking that will bring together U.S. government agencies; federal, state, and local law enforcement and prosecutors; trafficking-related non-governmental and commercial organizations; and academic researchers to share and discuss ideas on how to address some of the most challenging problems in human trafficking through the use of technology.

I hope that my testimony will provide a unique perspective on the challenges and opportunities of current research and technology in combating human trafficking and that the recommendations may help inform actionable policy initiatives.

THE USE OF TECHNOLOGY IN HUMAN TRAFFICKING

Human trafficking, also referred to as trafficking in persons, is a form of modern-day slavery that involves the use of force, fraud, or coercion for the purposes of involuntary labor and sexual exploitation. Because trafficking is often an unseen crime, it is hard to get accurate statistics of its prevalence; however, it is known to affect tens of million of victims worldwide and generates tens of billions of dollars in illicit profits annually [5, 6]. Human trafficking is a heterogeneous crime that takes on many forms, and one Non-Governmental Organization (NGO) has developed a typology of twenty-five different forms of human trafficking present in the U.S., each with different business models; trafficker and victim profiles; and recruitment and control strategies, that enable the facilitation of trafficking [7, 8]. While agencies across the U.S. government employ a diverse range of resources to combat human trafficking in the U.S. and abroad, this heterogeneity makes it a challenge to measure, investigate, and interdict [9, 10]. Technology plays a key role in many different facets of human trafficking, and will be detailed throughout this testimony.

The democratization of technology has fundamentally reshaped the world, from greater economies of scale in the commercial sector to dramatic shifts in strategic advantages in national security, and those facilitating human trafficking have also benefited from these technological advances. In the last decade, the advertising of sex trafficking victims has moved from the streets to the internet, providing greater efficiency and anonymity for traffickers and complicating the ability of law enforcement to disrupt these illicit organizations. Traffickers routinely use advanced technologies to conceal their operations and proceeds, from using encrypted communications on mobile phones, to leveraging cryptocurrency and elaborate money laundering schemes [11–13]. One area where these advances have had a significant impact is the federal criminal process in which investigators and prosecutors are routinely inundated with complex digital evidence including voluminous telephone records; loosely structured business records; forensic device extractions containing imagery, video, and audio; and information in foreign languages. These data are currently time- and human-intensive to analyze with limited purpose-built technology to assist, leading to missed connections and lost opportunities for interdiction and justice.

At the same time, a patchwork of commercial companies, NGOs, government laboratories, and academic institutions are developing both general purpose and focused point-solutions to specific human trafficking problems. To holistically describe all of the ways in which technology is used to counter human trafficking is beyond the scope of this document, but it is important to provide some specific examples of areas where novel impact is being made and to identify technology, process, and policy gaps that need addressing. To appropriately reduce the scope, the following technology examples will primarily focus on domestic sex trafficking operations, across state and federal echelons. One of the major reasons the counter human trafficking community has had more success in combating sex trafficking as opposed to the various forms of labor trafficking, is that commercial sex services rely on an open marketplace where demand, the buyers, can find supply, the providers. While nowhere near fully transparent, the commercial sex marketplace is observable, measurable, and like any market, able to be disrupted. Before delving into specific examples, it is important to discuss two major inherent factors that underpin the success of criminal process operations across the country at multiple echelons.

First, there is a wide disparity in investigative and prosecutorial resources across the federal government, states, cities, and towns. For example, some states have dedicated human trafficking response teams at the attorney general or district attorney level that both investigate and prosecute trafficking, while other regions may only have a handful of state or local police officers assigned to cover investigations across an entire state or city. Several states also have regional human trafficking task forces: grant-funded multidisciplinary anti-trafficking teams that pool prosecutors, officers, victim service providers, and other groups into a coordinated, collaborative organization. This disparity of resources hinders development of a more uniform national-level response to countering human trafficking. Second, there is a wide disparity in the availability of purpose-built technology to assist trafficking investigations and prosecutions. Some states have advanced capabilities such as electronic forensic exploitation teams, dedicated financial analysis cells, and in-house software developers. In other states, investigators and prosecutors have few purpose-built capabilities beyond NGO-developed tools and standard spreadsheet software. There is also a wide range in the cost of technology, with some NGO-developed tools provided free to law enforcement, while some electronic forensics tools cost tens of thousands of dollars in annual licensing and maintenance fees. High cost can be a significant to insurmountable burden for smaller agencies to access relevant technology to assist in investigations. Lastly, across this spectrum, investigating and prosecuting trafficking cases is significantly time- and human-intensive, often requiring over a year of work to complete a single case.

Technology to Measure Marketplace Supply

The first technology example focuses on systems to collect, structure, and visualize data from commercial sex marketplaces. The ability to find and characterize advertisements that connect providers and buyers is critical to the investigative process. Currently there are three major software platforms that investigators can use to search and analyze advertisements and user posts from commercial sex classified websites and buyer review forums. Together these platforms provide access to hundreds of active and inactive websites comprising several hundred million unique archived web pages of advertisements, provider reviews, and buyer discussion threads. Web-based interfaces allow authorized law enforcement users to query and filter ads on the basis of geographic region, keyword,

phone number, and other identifiers [14]. Users can upload photos of investigative interest, detect faces, and find advertisements with faces similar to the uploaded image [15]. Additional advanced capabilities for social network building, classification of advertisement text, and other features are available on a subset of platforms [16,17]. Capabilities under development will also enable advanced image recognition and filtering, such as determining which hotel chain a photo was taken in [18].

Technology to Interdict Marketplace Demand

Technology can be used to counter the demand-side as well as the supply-side of sex trafficking. The next example focuses on several NGOs that have developed buyer deterrence platforms to automate elements of buyer sting operations. Traditional sting operations target buyers knowingly prepared to engage in commercial sex services, where an undercover law enforcement agent posts decoy sex advertisements, poses as a provider when negotiating with the targeted buyer, and arrests the buyer upon arrival to a service location, such as a hotel room. Building on this approach, an NGO has developed a buyer deterrence platform that combines a text message back-end with an autonomous chat bot trained on conversations between sex buyers and undercover agents. When a buyer sends a text message to a phone number found in a decoy sex advertisement, the chat bot engages with the most relevant response from the transcripts it has been trained on. Subsequent interaction may lead to negotiating a service, price, location, and possibly establishing that the buyer is aware the provider is likely a minor. Once this phase is reached, the chat bot sends a deterrence message informing the buyer that purchasing sex is a crime and providing internet links to educational resources. Several days later local law enforcement send a message to the buyer informing them their phone number is now known to them and reminds them of possible arrests and fines. This system uses the threat of law enforcement action to deter buyers from seeking commercial sex in the future [19]. Another NGO has developed a similar system that uses a distributed network of human operators who engage buyers responding to decoy advertisements via a cloud-based text message and call center dashboard. Its intent is to have one-on-one conversations with buyers to raise their awareness of human trafficking and to change their attitude towards purchasing sex [20]. Both of these platforms aim to deter buyers and limit the need for resource-intensive law enforcement sting operations.

Digital Forensics Technology

The last example discusses the role of digital forensics in the prosecutorial process. State and federal trafficking investigations increasingly depend on evidence derived from the forensic extraction of data from cell phones, tablets, computers, vehicle systems, and other electronic devices. Cell phones have become integral devices for many people, capable of storing sensitive and intimate details of daily life. The same is true for phones owned by traffickers and victims, and the ability to reconstruct time-lines, patterns of movement, text communications, and social networks has become a critical tool for corroborating victim testimony and discovering incriminating information about traffickers. In the last decade, there has been an explosion of hardware and software for digital forensics [1]. Generally, forensic extractions begin with hardware that physically attaches to the device and use various sensitive and proprietary methods to subvert the manufacturer's access controls to expose the device's data and record it to a device image [21]. Specialized vendor software is used to read and decode the device image to enable messaging and call analysis, image and video

analysis, extraction of information from third-party phone applications, or retrieval of cloud-based information. Most of these tools are intended for law enforcement only and have sensitive technical capabilities, and almost all of them require search warrants or consent in order to be used. This aspect of digital forensics represents an area of human trafficking-related technology that is largely being solved by the commercial sector, and does not require federal research and development investment.

These examples illustrate some of the successes of commercial entities and NGOs in developing point-solutions to specific facets of the counter human trafficking problem. However, there is much work to be done at the federal level where multi-organizational research and development is needed to create solutions that otherwise may not be intrinsically driven by market-based or philanthropic use cases. The following policy recommendations represent steps the federal government could take to transform the research and development posture for creating, delivering, and making best use of technology to combat human trafficking. Each recommendation is scoped to be enacted independently, but would have a dramatic force-multiplier if enacted in concert.

RECOMMENDATION: INCREASE HUMAN TRAFFICKING R&D FUNDING

The most urgent need for applying technology to counter human trafficking is substantially increased federal funding for research and development efforts. Across the federal government, several agencies are funding human trafficking research, such as the Office to Monitor and Combat Trafficking in Persons at the U.S. Department of State, the Counter-Trafficking in Persons programs at U.S. Agency for International Development, the Bureau of International Labor Affairs at the Department of Labor, the National Institute of Justice at the U.S. Department of Justice, the Administration for Children and Families at the Department of Health & Human Services, the Science and Technology Directorate at the Department of Homeland Security, and others. The total weight of effort across these grants, solicitations, and other activities is estimated in the tens of millions of dollars per fiscal year; however, it is challenging to derive a holistic amount due to budget categorization and fidelity. Additionally, much of this funding is focused on academic research and studies, rather than on prototyping and development of new technology. R&D budgets to counter other types of illicit and organized crime, such as narcotics smuggling or counter-terrorism, are several times greater than those for human trafficking. Across the counter human trafficking community, academic and government researchers and NGOs have had to be creative in getting funding, by pursuing philanthropic sources and foundations; by developing intellectual property under non-human trafficking federal research initiatives and later applying it to human trafficking, and in some cases by gaining access to state-level forfeiture funds derived from successful prosecutions of traffickers. The scarcity of funding in size and in frequency limits the establishment of a community of engineers, scientists, and technologists who understand the human trafficking domain and can become practitioners in developing needed technology solutions year-on-year.

RECOMMENDATION: ESTABLISH AN INTERAGENCY R&D ENTITY

The interdisciplinary and heterogeneous nature of human trafficking, in the context of limited research funding, necessitates a fundamental rethinking of how to approach R&D initiatives. Under the current paradigm, independent solutions are solicited, funded, and developed within individual agencies, but are often not coordinated to yield the widest impact across interagency operations. These point-solutions become uncoordinated piece-wise improvements against a wide ranging problem, resulting in a more limited impact than if they were developed in concert with other initiatives as part of a broader research strategy or vision. The Victims of Trafficking and Violence Protection Act of 2000 (TVPA) established the President’s Interagency Task Force to Monitor and Combat Trafficking in Persons (PITF), a cabinet-level entity consisting of 19 agencies responsible for coordinating primarily policy initiatives across the federal government. What is now needed, is a PITF-like interagency structure specifically for human trafficking research and development, and could be designed after the Joint Interagency Task Force (JIATF) model used within the Department of Defense. A JIATF may be formed when the mission requires close integration of two or more coordinated U.S. government agencies, and uses a unique organizational structure to focus the organization on a single mission. A JIATF-like entity for counter human trafficking would be staffed and led by personnel from multiple trafficking-related agencies under a single director, and would have its own line of funding in order to provide for a unified effort; centralized planning and direction; and decentralized execution. The interagency process would require this entity to be especially flexible, responsive, and cognizant of the capabilities of the agencies it comprises, as well as of NGOs, FFRDCs, and industry, and must be empowered to take risk, even if those risks that don’t pay off. The creation of this autonomous, focused, and agile entity could revolutionize the funding, development, and operationalization of technology, while also improving collaboration and reducing duplication of effort.

RECOMMENDATION: ENHANCE R&D AGILITY AND TRANSITION

Many research and development efforts begin with a process of an agency soliciting for ideas around a general need area; down-selecting and funding proposals; and performers building material solutions based on their proposals, often without direct consideration of potential operational users. Additionally, within operation-centric federal agencies that have internal research directorates, there is often what is referred to as the *technology valley of death*, where new prototype capabilities developed by a research directorate were not fully informed by and developed in concert with the operations they seek to impact, and often fail to be adopted into mission directorates. A good development methodology must take into account procedural and institutional barriers that can cause friction and affect technology transition.

To mitigate this, human trafficking research and operational agencies should adopt an agile user-centric development paradigm. To achieve this, operators need to be joint stakeholders at every stage of the development process, from the codifying of requirements to testing and deployment. Knowing the urgent problems in need of solutions is critical to this process, and the government should engage in periodic studies to reduce duplication of effort across other agencies, industry, and NGOs. Agencies should move to a co-development model where engineers and developers

are embedded within operational organizations. Such a model has been used to great effect in the special operations community. This enables the technology to adapt to the mission much more quickly, and the mission to evolve with continual advances in the technology. Also, modern software development methodologies should be employed such as automated testing, continuous integration, and continuous delivery to users, in order to more efficiently address gaps between developers, IT infrastructure, and operations. All of these methods will increase development agility, improve technology adoption, and enhance operations, maximizing limited human trafficking research and development funding. Lastly, federal initiatives should be structured in such a way that developed technologies can be also transitioned to state and local partners, as those agencies are often the most in need of new technology and have significant opportunity for impact.

RECOMMENDATION: CROSS-LEVERAGE GOVERNMENT TECHNOLOGY

Often technology developed in one mission area of the government can directly be applied or can be modified for use in a different mission area. For example, many of the capabilities developed in the Department of Defense and the Intelligence Community to characterize and interdict terrorist networks, have strong corollaries to human trafficking networks. Similarly, tools and techniques developed for investigating traffickers could also be used for other missions, such as narcotics trafficking or white collar crime. An example of this cross-leveraging is the Defense Advanced Research Projects Agency's MEMEX program, which developed tools to index illicit marketplaces on the deep and dark web [22]. As part of the MEMEX effort, software developed by the program's performers was posted to open software repositories on the internet, and two of the major law enforcement tools that index commercial sex marketplaces were built with components that derived from the MEMEX software catalog [14, 23]. This is an example of technology transition and reuse from government research to NGOs, enabled by an open software catalog.

To increase opportunities for cross-leverage, the government should establish an illicit network technology working group, to create a conduit for sharing research and technical capabilities across agencies. This working group could include representation from federal law enforcement agencies, the intelligence agencies, the special operations community, and specialty organizations, such as the Combating Terrorism Technical Support Office and the Office of Terrorism and Financial Intelligence.

RECOMMENDATION: MEASURE EFFECTIVENESS AND ASSESS IMPACTS

A key component of a coordinated research and development strategy is a process to measure progress against an objective. While federal and state agencies currently track performance statistics such as the number of investigations initiated, the number of individuals prosecuted, and the number of victims provided with services, no measures of merit exist to assess the effectiveness of the collective government response to human trafficking. In order to frame these numbers in the context of a measure of effect, much more work needs to be done on national-level models for estimated vulnerability, prevalence of trafficking, and buyer demand, as many in the federal and NGO human trafficking community have noted [6, 24–26]. Specific to technology initiatives, measures of performance and effectiveness need to be developed alongside research projects, so that the impact

of these investments and their resultant capabilities can be assessed. Example metrics include how many more cases were initiated as a direct result of instantiating state and federal information sharing technology or how much time was saved during evidence analysis due to a specific automated software analytic. Implementing meaningful measures of merit will require continual effort and institutional change, but can begin by incorporating measurement and assessment strategies into current federal programs.

RECOMMENDATION: ADDRESS EXISTING TECHNOLOGY GAPS

In order to enhance the federal government's ability to counter human trafficking, the following technology, process, and operational gaps should be considered for future research and development initiatives. These findings are based on a multi-year process of interviews, assessments, and work-domain observations of over 45 federal, state, and local agencies; federal and academic researchers; private sector companies; and NGOs involved in counter human trafficking activities. Accordingly, these are meant to be a representative sample of actionable short-term needs from specific facets of human trafficking rather than a complete or holistic accounting. Greater detail on many of these recommendations appears in the *Human Trafficking Technology Roadmap* [1], and other studies [2, 27–29]. The recommendations apply across sex trafficking, labor trafficking, or both, and are focused on domestic and bilateral trafficking initiatives with other nations, but not fully international initiatives. Lastly, the recommendations are technical in nature and do not discuss general process improvements or issues that can be addressed with cultural, organizational, and non-technological interventions. The technology gaps and recommendations group around four selected areas: investigations and prosecution, information sharing, measurement of trafficking, and marketplace interdiction. Each of these is addressed below.

Investigations and prosecution: Technologies that can assist federal and state law enforcement and prosecutorial organizations in investigating complex cases involving the analysis of large quantities of complex heterogeneous data.

1. **Trafficking Signatures.** Indicators of trafficking or illicit commercial sex operations; which can appear on sex advertisement sites, in social media accounts, or within communications between individuals; can be important cues for investigators. These indicators can be based on specific language usage in speech or text, or based on visual appearance, such as specific objects or scenes in imagery or video. A repository and taxonomy of known indicators and signatures accessible to federal, state, and local law enforcement organizations should be developed, enabling the search and retrieval of known signatures, and labeling and submission of new ones.
2. **Vulnerability Monitoring.** Traffickers regularly use social media to look for susceptible or vulnerable individuals to contact and groom for later exploitation. Vulnerability indicators include sexually suggestive photos or postings of content and hash-tags with themes associated with familial trouble, truancy, drug use, running away, and depression. A capability should be developed to monitor publicly available social media profiles in a given region and provide warnings to law enforcement and social service agencies when a profile begins to express

indicators associated with vulnerability, interest in the commercial sex industry, or potential trafficking.

3. **Knowledge Management.** Many law enforcement agencies have limited case and knowledge management technology and often employ ad-hoc analysis logs and spreadsheets to keep track of discovered information during an investigation. A purpose-built integrated case and knowledge management platform for collaborative trafficking investigations across multiple law enforcement and prosecutorial organizations, should be acquired or developed. The capability should include natural-language processing to extract and structure pertinent entities and metadata from primary evidence stored in the system, and should provide full-text search functionality.
4. **Data Templates.** Commercial entities such as banks and social media platforms use unique data and document formats when responding to judicially-compelled record requests. Several law enforcement organizations are building capabilities to read and parse these formats, incurring collective duplication of effort. A working group of commercial tool vendors, law enforcement agency software teams, and other stakeholders should be established to develop templates for common judicially-compelled record formats and forensic device reports, and develop the structured extraction software libraries for each format.
5. **Data Enrichment.** Investigators often have to work with complex data formats that are difficult to use efficiently, such as scanned business records, photos of physical evidence, full social media profile archives, and electronic device forensic extractions. An integrated software capability should be developed to leverage natural-language processing, computer vision, machine learning, and other techniques to extract, structure, and enrich information contained in primary evidence. Textual information, such as names, locations, organizations, phone numbers, IP addresses, and other information should be extracted automatically using statistical and rule-based methods. Faces, objects, and text overlays should be extracted from scanned documents, images, and videos, and used to enrich the source media with metadata. Social network analysis techniques should be employed to find connections between information within and across documents and data, in order to automatically discover relations between pieces of evidence to accelerate triage, analysis, and confirmation of entities in the investigation.
6. **Telecommunications Analysis.** Information derived from mobile, landline, and calling card phone records is a cornerstone of trafficking investigations. Investigators may receive months to years of call records in response to court orders. These records are often processed and analyzed with basic analysis techniques, such as ranked call frequency, using common spreadsheet software, which does not scale for complex cases. A capability should be acquired or developed to extract, structure, and store call records, apply social network analysis techniques to enable in-depth analysis of call behaviors, and represent spatiotemporal data on a map. The deployment of these tools should be augmented with personnel training in social network analysis techniques and best practices.

7. **Financial Analysis.** Illicit commercial sex operations use complex financial processes in order to conceal the generation, transfer, and storage of their proceeds, and uncovering these activities can be critical to successful trafficking investigations. These processes can range from small-scale all-cash schemes to large-scale complex international money laundering operations using the global financial system. Capabilities should be developed to better process, store, and analyze financial data, including large amounts of bank transaction and money transmitter records to more easily build integrated spatiotemporal networks of activities. Additionally, automated detection and alerting capabilities should be integrated for known indicators and coordinated behaviors, such as those from the Financial Action Task Force (FATF), the Financial Crimes Enforcement Network (FinCEN), and the broader anti-money laundering community.
8. **Video Analysis.** Many human trafficking cases often involve obtaining closed-circuit video surveillance footage from hotels, stores, banks, and other businesses that are associated with trafficking operations. However, current analysis methods are inefficient, with limited technology to assist. Video analytic capabilities should be employed to reduce the time- and human-intensive elements of surveillance video analysis. Technologies to consider include attribute-based search; which allows a user to find video segments based on attributes such as the color of as an article of clothing; and time compression or video summarization; which allows segments of video with little or no activity to be removed, focusing analysis on scenes with significant activity. Additionally, facial recognition and object detection techniques could be employed, if the video resolution and the camera geometries are suitable, to enable common image recognition techniques.
9. **Speech Analysis.** Investigators and prosecutors spend large amounts of time listening to, transcribing, and analyzing phone call speech content. Speech processing technology offers the potential for reducing the time- and human-intensive nature of call analysis. This technology may include speaker biometrics, to help keep track of unique parties on calls; language identification, to survey calls to determine what linguist personnel are required; and automatic speech recognition, to convert call audio into partial text transcripts. Partial transcripts can be helpful to assist in the triage of large volumes of calls, and can be processed with analytic methods, including word-frequency analysis, topic modeling, and text summarization; text-to-text machine translation; keyword spotting; and other techniques. While these technologies will not replace the need for manual transcription of calls for evidentiary or trial purposes, they can serve as critical tools for directing and prioritizing scarce resources to the highest calls of interest. Lastly, these component technologies could be combined to create a machine-assisted transcription system.

Information sharing: Technologies that enable sharing among the counter human trafficking community while addressing such concerns as victim re-traumatization, disclosure of personally identifiable information, and sharing protected data.

10. **Enterprise Federation.** Many federal agencies have trafficking-relevant information stored in disparate databases with no easy way to correlate information across both intra- and inter-agency systems, due to technology, policy, and vendor limitations. An enterprise federated

search solution should be pursued to enable real-time, simultaneous search of multiple disparate data sources, with correlation and display of results in a useful format to the user. Federated search across government enterprises will lead to increased information sharing and time savings.

11. **Data Partnerships.** Many novel data sources relevant to counter human trafficking efforts are not shared due to concerns about traumatizing victims, releasing personally identifiable information, or loss of control over proprietary data sets. A bottom-up approach to building collaborative data sharing agreements should be pursued among small groups of counter human trafficking organizations on a case-by-case basis in order to encourage sharing of novel data sources. Elements of this approach include identifying novel data sources and organizations willing to share them, developing public-private incentive mechanisms, implementing a system to instantiate a pilot sharing program, and extending this program to include other sources and organizations.
12. **Encrypted Sharing.** Many organizations are unable to share trafficking-related data with other organizations due to restrictions on sensitive data. This data can include personally identifiable information from the public sector, data collected as part of law enforcement operations, or medical information protected under the Health Insurance Portability and Accountability Act. The inability to share and co-mingle multi-modal data precludes a more complete picture of many facets of trafficking. Recent advances in computer science have enabled the ability to perform certain analytical operations on data that has been encrypted, without revealing the underlying sensitive data and without the pitfalls inherent in data anonymization [30,31]. One or more pilot programs should be considered to assess the utility of these encrypted analytic methods, with law enforcement, health care, and NGO participation.

Measurement of trafficking: Methods and studies needed to understand supply and demand in commercial sex marketplaces given incomplete and inconsistent data, in order to measure impact of counter human trafficking efforts.

13. **Measure Outcomes.** Many practitioners in the counter human trafficking community desire the ability to quantitatively understand the effect of their respective efforts on reducing the prevalence of trafficking. For example, state law enforcement agencies have the ability to perform sex buyer stings almost daily, but are unsure whether these stings have a general deterrence effect and whether they are an effective use of resources. Similarly, prosecutors who require convicted buyers to attend human trafficking awareness training in exchange for ex-punction of charges, want to know whether training results in lower recidivism. Outside of law enforcement, there is broad interest in understanding the impact of counter human trafficking statutes, operations, and awareness campaigns. An interdisciplinary working group should be organized to develop strategies to collect and model data to assess the impacts of counter human trafficking activities.

14. **Data Standardization.** A robust, quantitative understanding of the scale and scope of trafficking can be used to raise awareness, improve resource allocation, guide public policy by enabling quantitative evaluation of policy effectiveness, and ultimately reduce the prevalence of trafficking. Building such an understanding is challenging due to incomplete and inconsistent data collection, and researchers employ a variety of methods to address these challenges [32]. For example, differences in legal statutes can affect how trafficking-related activities are prosecuted; often traffickers may be prosecuted for other crimes that are easier to prove than trafficking. Inconsistencies can also arise from how trafficking activities are recorded geospatially and temporally. For example, some organizations may aggregate information annually or at the state level, while others may use finer granularity; or organizations may use different procedures for recording trafficking activity that occurs over wide geographic areas or for long durations. These data issues result in researchers extrapolating the data they have, rather than modeling from the data they want. A working group should be established to design data standards to improve the uniformity of data reporting among stakeholders at the local, state, and national levels, and to identify data that should be collected in support of longitudinal and multilevel analyses.
15. **Model Prevalence.** Accurate vulnerability and victimization prevalence estimates are crucially important to the counter human trafficking community because they drive awareness of the scope of the problem and how to allocate resources to address it. Many have advocated for a nationwide prevalence model, however the lack of primary data and a secure way to integrate those data precludes such a model [6, 24]. An integrated system should be developed to enable longitudinal, multilevel, and other studies of victim prevalence using a broad array of data sources at local, state, regional, and national levels. Potential data sources could include law enforcement reporting and arrest data; judicial data; case work; trafficking tip line reporting; hospital and medical services records including public health human trafficking reports; and victim services provider data. Minimization of data and sharing concerns should be addressed using recommendations made elsewhere in this document.
16. **Model Demand.** The demand for commercial sex has received less attention than victim prevalence. Studies often use surveys to attempt to understand buyer attitudes and motivations [25, 26]. While such studies are useful, there is a need for buyer demand modeling that leverages new data sources and methodologies to build a more complete understanding of demand over time, and at the local, state, and national levels. An automated capability is needed to measure marketplace attributes from sex advertising forums and buyer review sites, and methods for continuous measurement of buyer demand should be developed, to enable an understanding of the impact of policy changes, counter-demand activities, and other factors.

Marketplace interdiction: Technologies for augmenting state law enforcement in disrupting supply and demand in commercial sex marketplaces, in order to reduce human trafficking.

17. **Buyer Characterization.** While law enforcement would prefer to target high-frequency buyers during counter-demand operations, identifying buyers and characterizing their behavior are difficult. Technologies to monitor buyer review forms and profile high-frequency buyers

should be explored, with the intent of developing signatures that could be matched with activity on the open internet, possibly leading to buyer identification. Additionally, a federated national-level sex buyer repository should be developed that allows storing, searching, and sharing of data collected from buyer stings and from demand deterrence platforms.

18. **Demand Operations.** Buyer sting operations often involve time-intensive activities such as developing and posting decoy advertisements and negotiating with buyers. An integrated capability for workflow automation should be developed to make sting operations more efficient and effective. Partnerships with demand-deterrence NGOs should be explored to cross-leverage technology of mutual benefit in order to scale operations and achieved greater efficiencies.
19. **Undercover Personas.** The use of undercover social media personas is widespread in law enforcement operations. Such personas are time-intensive to create and maintain, and many agencies use poor operational security practices that could compromise undercover assets [33]. An integrated system should be developed to semi-automatically generate social media personas based on user-defined attributes, leveraging managed attribution services to protect personas and law enforcement personnel. Robust user training should be provided to mitigate the risks associated with this system.

CONCLUSION

Human trafficking is a challenging and pervasive problem that necessitates broad action and bold ideas. Thoughtfully designed technology can empower the collective counter human trafficking community and disrupt these illicit operations. Increased research and development for counter human trafficking initiatives holds the potential make a tremendous impact by accelerating justice and hastening the healing of victims. I want to thank you for your interest in this pressing issue, and for the opportunity to prepare this testimony for you.

ABOUT THE AUTHOR

Matthew Daggett is a member of the technical staff in the Humanitarian Assistance and Disaster Relief Systems Group. He joined the Massachusetts Institute of Technology's Lincoln Laboratory in 2005, and his current research focuses on developing analytic technologies and systems for the study of dark and illicit social networks, such as human trafficking organizations. He has pioneered novel operations research methodologies and quantitative human-system instrumentation to design and measure the effectiveness of prototype technologies and processes for complex sociotechnical systems. He has expertise in remote sensing optimization, social network analysis, computer vision, natural-language processing, data visualization, and the study of team dynamics and decision making. He holds a bachelors degree in electrical engineering from Virginia Polytechnic Institute and State University.

SELECTED PUBLICATIONS

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