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Predicting What They Use

*The Anticipating Terrorist Technology Adoption to Secure the Homeland (ATTASH)
Project*

ATTASH Mission Statement

Deliver a sustainable capability to:

1. **Identify problematic emerging technologies** with respect to terrorism against the homeland,
2. **Prioritize actor related threats** involving these technologies, and
3. **Locate opportunities** for interdiction and prevention before these emerging technologies cause harm to the homeland.

Project Overview

PROBLEMS TO SOLVE

- Emerging technologies are force multipliers that can advance more rapidly than defenses and have been successfully used by VNSAs.
- National Security Strategy 2002
- DHS Strategic Framework 2019

METHODS

Horizon Scanning

+

Terrorist Technology Adoption Model for the domestic context

Year 1 focus: CBRN

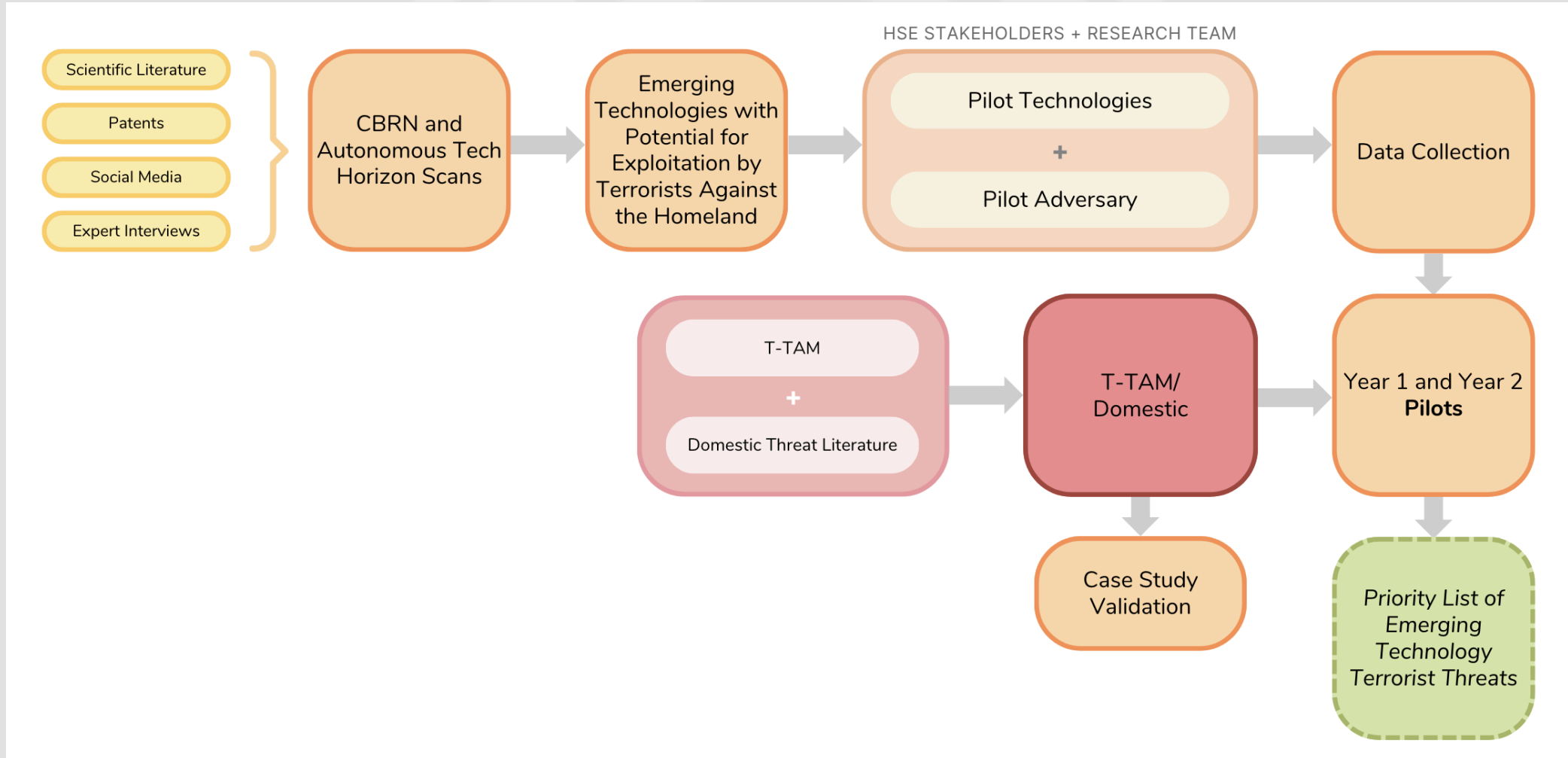
Year 2 focus: Autonomy

PRODUCTS

- CBRN / Autonomy Threat Horizon Scans
- Validated and Revised Terrorist Technology Adoption Model/Domestic (T-TAM/D)
- Pilot Implementation of T-TAM/D to yield a ranking of the particular technology-terrorist dyads of greatest concern

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ATTASH Process



1. Horizon Scans

- Objective: *identifying those emerging technologies of potential homeland security concern.*
 - Offensive focus: only those that could be utilized by violent non-state actors
 - Only technologies with developments reported in last five years
 - Looking for ‘weak signals’ so cast a broad net and err on the side of inclusion.
- While horizon scans often serve as the first phase in broader foresight activities, they do not by themselves constitute a threat assessment.
 - Plausibility is sufficient
 - Magnitude of the threat (e.g., technical hazard, likelihood of pursuit, capability of adversaries to exploit it) reserved for subsequent analysis [e.g., TTAM Model]
- Scan involved systematic search process to identify signals in both mainstream and “fringe” sources, as well as in-depth interviews with subject matter experts.

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YEAR 1 CBRN Horizon Scan Overview

Broad/Concentric Signal Search (>800 sources)

- Mainstream Literature
- Fringe Materials



Signal Coding
(604 signals)

Expert Input
(13 interviews)

Clustering, Analysis and Synthesis (57 insights)

Advanced Imagery & Image Processing

Advances in and increased availability of image processing could assist terrorists in locating CBRN materials, planning CBRN attacks and identifying vulnerabilities at facilities where CBRN materials are housed.

Technology Type	ISR/Planning Technology
Current Status	Limited Commercial Availability
Trend Value	Trend Increasing
Potential Strategic Impact on HS	Low
Time Horizon	
Limited Commercial Availability	Presently
Widespread Commercial Availability	2-5 years

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YEAR 1 CBRN Horizon Scan Write-Up Samples

Electromagnetically Activated CW or BW

Electromagnetically Activated CW or BW

Technology to activate reactions with EM waves could enable new forms of binary CW or BW deployment, possibly even creating toxic molecules or activating diseases at a standoff distance.

Technology Type	Harm Agent Technology; Delivery Method Technology
Current Status	Prototyping or Proof of Concept
Trend Value	Discontinuity: Black Swan
Potential Strategic Impact on HS	Low
Time Horizon	5-10 years Unknown

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Electromagnetically-Activated CW or BW

BACKGROUND

Microwave- and light-activated chemical reactions are recent developments in which light or microwaves are used to catalyze chemical reactions.[A,B,C] These technologies often arise as part of the shift to "green chemistry", where researchers are seeking to develop new chemical production pathways that utilize fewer solvents, raw materials, or heat to have environmental benefits.

CURRENT STATUS AND EXPECTED TRAJECTORY

Light- and microwave- assisted chemical synthesis is mostly still located at the prototype stage, but is widespread in many laboratories. Additionally, research in this area has become increasingly popular over the past decade. One illustrative approach that is undergoing research is photodynamic therapy, which has potential use in treating cancer. The salient finding is a cancer killing molecule where precisely targeted light is used to activate or "turn on" a drug to kill cells. While currently used mostly to treat skin cancers, researchers want to know if there is a way to safely get the light to cancers that are deeper inside the body.[D]

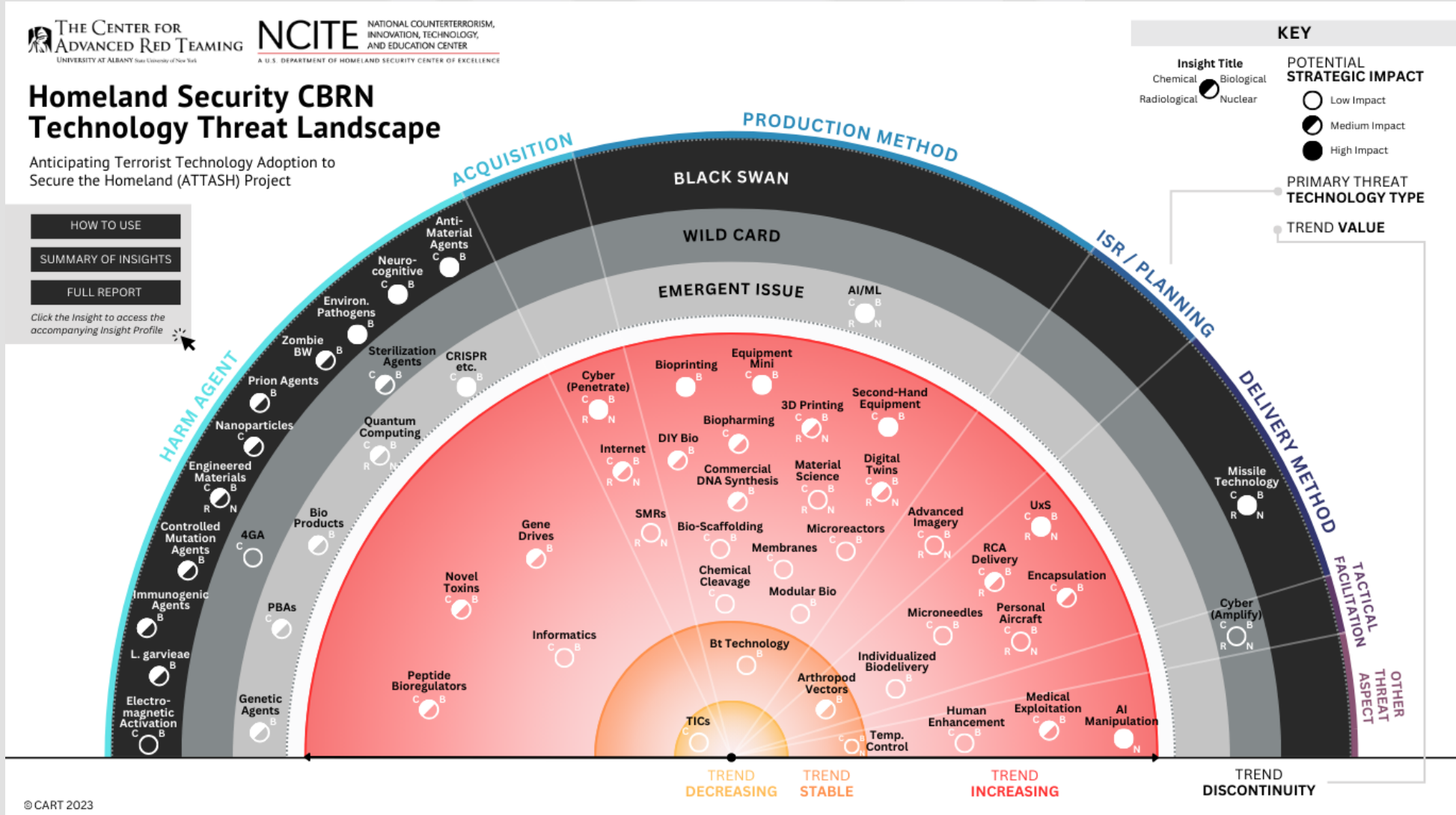
POTENTIAL RELEVANCE FOR VNSA USE IN THE DOMESTIC CONTEXT

- **Novel forms of Binary CW:** The basic idea of binarization as it relates to CW is to have two relatively non-toxic / innocuous chemicals which when combined produce a highly toxic chemical agent. This facilitates delivery (and often production as well), since the non-toxic components can be easily and safely stored and transported while separated, but then combined at or shortly before the time of the attack. While binary CW have a long history, synthesis by exposure to light or microwaves could perhaps even lead to CW which are inert until exposed to electromagnetic radiation of certain wavelengths. New technologies that utilize electromagnetic waves such as light or microwaves to catalyze chemical reactions might allow for new forms of binarization – either membranes that can be perforated from some distance away or perhaps for non-toxic chemicals to convert to toxic chemicals directly upon exposure to electromagnetic radiation of a specific wavelength. This could be especially problematic from a Homeland Security perspective if it allows a chemical to spread widely (e.g., be ingested by many people) and then at a predetermined time expose them to the EM waves to make the previously inert chemical toxic.
- **Novel activation of BW:** While more speculative than on the CW side, it is conceivable that similar methods could at some point be used to activate or facilitate the growth of specific microorganisms, or induce them to release toxins, upon exposure to light or other electromagnetic radiation.

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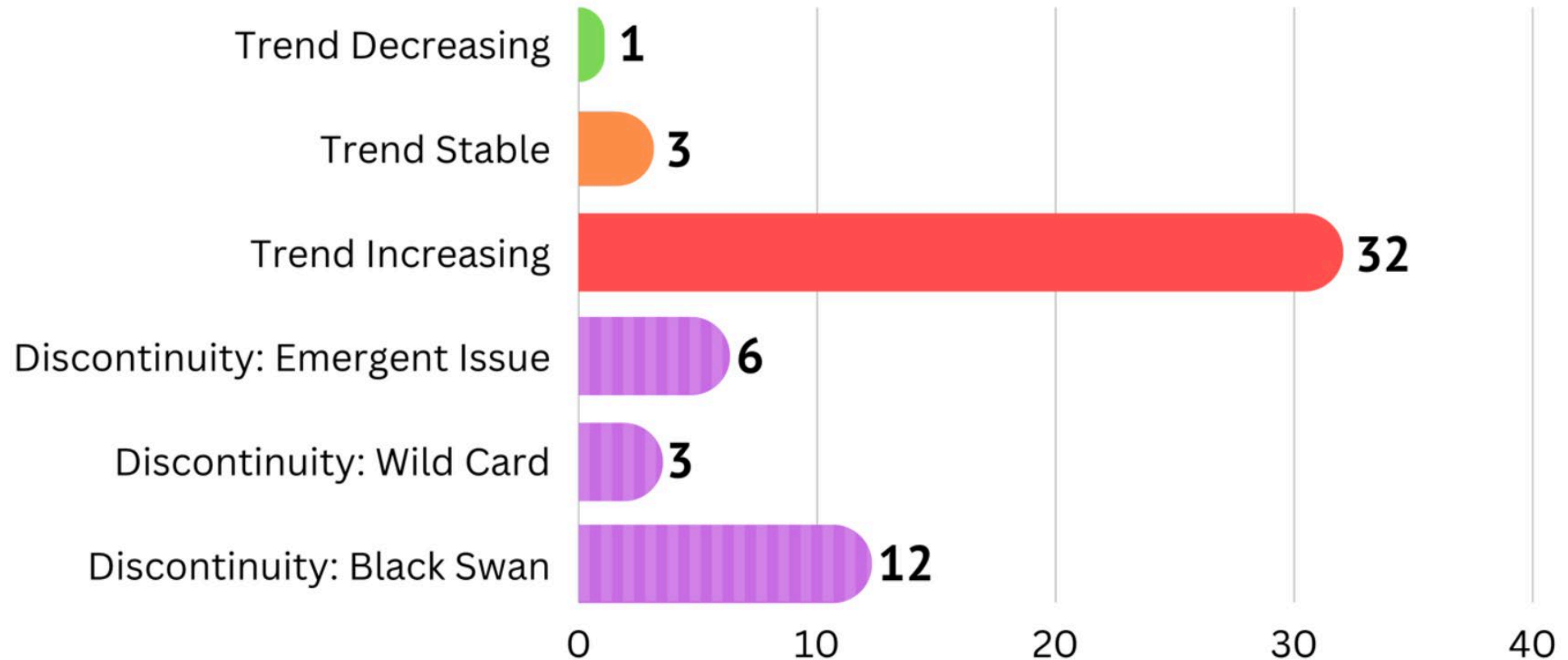
YEAR 1 CBRN Horizon Scan Infographic



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YEAR 1 CBRN Horizon Scan Analysis – Characterization of Change

Figure 4: Trend Value Change Categories by Insight Frequency



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YEAR 1 CBRN Horizon Scan Analysis – Potential Strategic Impact

Figure 2: Frequency of Insights by Potential Strategic Impact

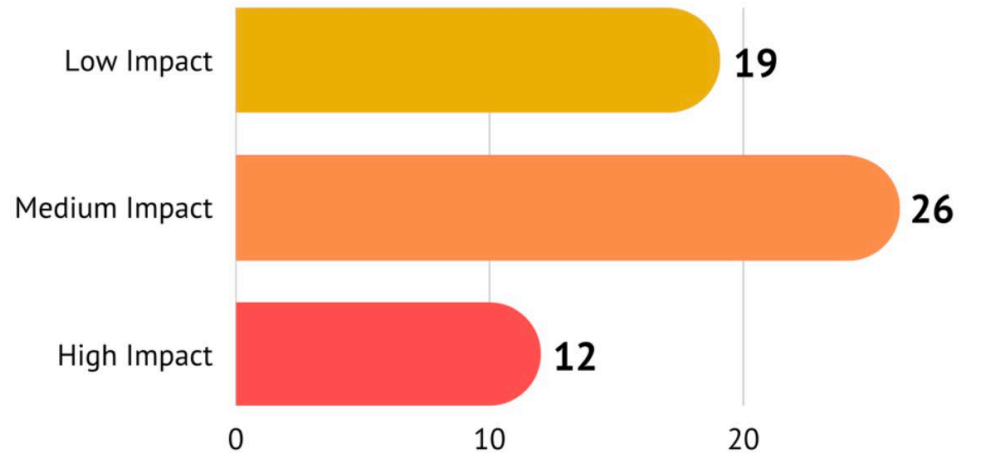


Table 3: List of Emerging CBRN Technologies or Technological Developments with Potentially High Strategic impact on Homeland Security

Technology / Technology Cluster (alphabetical order)	
Artificial Intelligence and Machine Learning (AI/ML)	Cyber to Penetrate CBRN Facilities
Anti-Materiel Agents	Missile Technology
Bioprinting	Neurocognitive Technologies
Broad-Spreading Environmental Pathogen	Production Equipment Miniaturization
Manipulating AI to Escalate Conflict	Second-Hand Equipment Availability
CRISPR and Other Advanced Gene Editing Techniques	Unmanned Systems (UxS)

Year 2 Autonomous Technology Horizon Scan

- In conjunction with DHS, the selected technology domain was: **Autonomous Technologies**
- This covers recent and future developments in:
 - *Autonomous vehicles as weapons*
 - *Drone swarms*
 - *AI systems*
 - *Etc.*
- ***Horizon Scan to be completed in Summer 2024***

2. TTAM (Domestic) Model & Tool

- Integrates ***technical aspects of emerging technologies + social, organizational and strategic features*** of the malicious actors who could employ them.
 - Focuses on the **terrorist-technology dyad** as the primary unit of analysis
- Builds on a **novel socio-technical model** of terrorist technology adoption
 - Embeds model in a practical tool to analyze the *relative likelihood of successful* pursuit and adoption

TTAM (Domestic) Model & Tool (Cont.)

- Contributing factors approach based on prior theoretical and empirical work in both the terrorism and technology adoption literatures (incl. sociology, management science, cognitive psychology, military history)
- Two sub-models with very different types of outputs:
 - **Decision Sub-Model:** likelihood of a terrorist actor seeking to pursue the acquisition of a particular technology (focuses on subjective choice).
 - **Success Sub-Model:** likelihood that the terrorist actor will successfully adopt the technology (focuses on objective outcome).
- Innovations: Updated theoretical foundation; Deterministic→Probabilistic; Known Terrorist Groups Only→Lone Actors / Cells / Archetypes; Interaction Effects

T-TAM (Domestic) Advantages

- Built to reflect **specific actors** known to be prevalent *domestic threats* + *ability to model terrorist archetypes*
 - => **lone actors and autonomous cells**, which by their nature are almost never known to law enforcement agencies prior to their becoming involved in criminal activity, can be modeled in T-TAM (D).
- For example, T-TAM (D) can model potential adoption by an **Incel-inspired lone actor**
 - Input probability distributions that reflect:
 - Prior behaviors of similar actors in the United States
 - Analyst expert judgment
 - Monte Carlo analysis then constructs thousands (or millions) of plausible individual Incel-inspired lone actors and assesses the adoption likelihoods of each of these, yielding an overall threat picture.

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T-TAM Domestic Variables

Actor Variables			
Actor Environment			
Variable Name	Success Model	Decision Model	
Underdeveloped Infrastructure	Yes	Yes	
Lack of Social/Political Openness	Yes	Yes	
Intense Security Pressure	Yes	Yes	
Very Low Security Pressure	Yes	Yes	
Possesses State Sponsor	Yes	Yes	
Highly Networked (In General)	Yes	Yes	
Highly Networked (With Other VNSAs)	Yes	Yes	
Demonstration - 1st Degree (Matched with Technology Type)	Yes	Yes	
Homophily Boost: Dem 1st Degree	No	Yes	
Demonstration - 2nd Degree (Matched with Technology Type)	No	Yes	
Homophily Boost: Dem 2nd Degree	No	Yes	
Change Agent Proselytization (General)	No	Yes	
Homophily Boost: Change Agent Proselytization (General)	No	Yes	
Change Agent Proselytization (Specific Technology)	Yes	Yes	
Homophily Boost: Change Agent Proselytization (Specific Tech)	No	Yes	
Opinion Leader Proselytization (General)	No	Yes	
Homophily Boost: Opinion Leader Proselytization (General)	No	Yes	
Opinion Leader Proselytization (Specific Technology)	No	Yes	
Homophily Boost: Opinion Leader Proselytization (Specific Tech)	No	Yes	
Serendipitous Acquisition	Yes	Yes	
Actor Structural Characteristics			
Variable Name	Success Model	Decision Model	
Cohesiveness	Yes	Yes	
Group Size	Yes	Yes	
Group Age	Yes	Yes	
Specialized R&D	Yes	Yes	
Centralization	Yes	Yes	
Spatial Proximity of Organization Elements	Yes	No	
Actor Decision Making Characteristics			
Variable Name	Success Model	Decision Model	
Risk Tolerance	No	Yes	
Determination	Yes	No	

Technology Variables			
History			
Variable Name	Success Model	Decision Model	
Number of Successful Prior Adopters	Yes	Yes	
Requirements for Adoption			
Variable Name	Success Model	Decision Model	
Technology Techne Required (Production/Weaponization)	Yes	Yes	
Technology Techne Required (Deployment)	Yes	Yes	
Technology Techne Required (Overall)	Yes	Yes	
Technology Metis Required (Production/Weaponization)	Yes	Yes	
Technology Metis Required (Deployment)	Yes	Yes	
Technology Metis Required (Overall)	Yes	Yes	
Technology Acquisition Resources Cost	Yes	Yes	
Domain Modification Required	Yes	Yes	
Performance Characteristics			
Variable Name	Success Model	Decision Model	
Lethality Provided (Candidate Technology)	No	Yes	
Safety Provided (Candidate Technology)	No	Yes	
Operational Footprint Provided (Candidate Technology)	No	Yes	
Novelty Provided (Candidate Technology)	No	Yes	
Reliability Provided (Candidate Technology)	No	Yes	
Size of Requirement Deployment Team (Candidate Technology)	No	Yes	
Socio-Economic Disruption Provided (Candidate Technology)	No	Yes	
Ability to Overcome Countermeasures (Candidate Technology)	No	Yes	
Existence of Alternatives	No	Yes	
Availability Characteristics			
Variable Name	Success Model	Decision Model	
Availability of Information	Yes	Yes	
Availability (Whole Technology)	Yes	Yes	
Availability (Raw Materials)	Yes	Yes	
Active Opposition of Possessors	Yes	Yes	

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T-TAM Domestic Actor Input Sample

Variable	Question	Option Description	Option	Value	Justification
Actor Environment					
14	Underdeveloped Infrastructure	To what extent is the infrastructure in the area (usually country) where the actor is based developed? (Note: this should be based on general research about the area where the actor is based. While it is up to the discretion of the coder, some potential indicators of underdeveloped infrastructure are whether the total electricity consumption per capita is <1,000 kWh per year - see https://data.worldbank.org/ , or if the UN's list of least developed countries - https://www.un.org/ohrli/content/list-ldcs) (note: since some countries have vast differences in development across internal regions, even if the country is developed, if the actor is based in a particular part of the country with underdeveloped infrastructure, this can still be coded as "Underdeveloped"; conversely, even if the country is in general underdeveloped but there is good infrastructure where the actor is based, e.g., in a capital city, then this can be coded as not being underdeveloped)	Developed / Less Developed	95 %	A small percentage is allocated for less developed, in the event that a member of this actor/group chooses to live remotely in an undeveloped area given their activities.
15		Underdeveloped	5 %		
16			100 %		
18	Lack of Social/Political Openness	Is the society in which the actor is based (or operates most extensively) relatively socially and politically (Note: while this is ultimately up to the discretion of the coder based on their research, a good general guide is Freedom House ratings: https://freedomhouse.org/countries/freedom-world/scores , although "Partly Free" ratings will need to be investigated further with additional sources).	Rated as "Free" by Freedom House	Open	100 %
19		Rated as "Not Free" by Freedom House	Not Open	0 %	100 %

Actor Structural Characteristics					
200	Cohesiveness	How cohesive is the group?	Active infighting / on the verge of a split	Very Low	0 %
201	(N/A for lone actors)		Characterized by a high degree of internal factionalization and/or extensive divisions of authority.	Low	5 %
202			Exhibits some internal factionalization and/or divisions of authority, but the majority of members are aligned with the goals of a central leadership.	Moderate	15 %
203			Exhibits little or no internal factionalization and almost all members are aligned with the goals of the central leadership.	High	80 %
204				Total	100 %
206	Group Size	Does the actor have 100 or more members?	If group has >= 100 members	Yes	0 %
207			If above does not apply	No	100 %
208					100 %
209					
210	Group Age	Has the group existed for 5 or more years? (Note: only applies to formal organization or cell)		Yes	50 %
211	(N/A for lone actors)			No	50 %
212					100 %
213					
214	Specialized R&D	Does the actor possess a specialized unit / organ whose purpose is to conduct research and development? (Note: this refers to a formal functional element that is responsible for conducting research and development that is to at least some degree insulated from the day to day operations of the organization. It can range from a separate unit that the leaders dedicate to developing new weapons to a single member who is given their own workshop and allowed to take the time to tinker to see what new things they can come	There is evidence that the actor has a specialized R&D unit.	Yes	10 %
215	(N/A for lone actor)		If above does not apply.	No	90 %
216					100 %
217					
218	Centralization	How centralized is the group with respect to its structure and decision making authority? (Note: take into account both the	A single leader or set of leaders in a home base making all major decisions and/or hierarchical organization of command. [Mechanistic/Hierarchical]	Highly Centralized	100 %
			Specialized leadership, but multiple cells that have		

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T-TAM Domestic Technology Input Sample

1 ATTASH Pilot Technology Coding

2

3 Name of Coder: **Anna Wetzel**

4

5 Name of Technology Being Coded: **2nd Hand Equipment - Mid-Range Objective (Last gen equipment)**

6

7 Type of Technology: **Chemical** *if Other:*

8

Variable	Question	Option Description	Option	Value	Justification	
History						
13	Number of Successful Prior Adopters (Note: we are speaking here of adoption in the context of terrorism or related activities, not merely successful adoption commercially or in the research world.)	How many other terrorist organizations or violent non-state actors have previously adopted this technology?		0	100 %	Not particularly observable, so impossible to say how many have previously used second hand equipment to produce explosives, drugs, etc. No explicit cases of using secondhand equipment, but the origin of the equipment is not usually the focus of investigations. I'm comfortable putting a 0 because it's not something that is likely to be demonstrated explicitly in a way that will call attention to it as a possibility.
14			1	0 %		
15			2-4	0 %		
16			5-8	0 %		
17			9-10	0 %		
18			>10	0 %		
19				100 %		
Requirements for Adoption						

20

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22

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Ready Calculate Accessibility: Investigate

109	Ability to Overcome Countermeasures (Can defensive countermeasures be overcome?) (Note: By defensive countermeasures, we are referring to measures put in place to detect, prevent, respond to or otherwise mitigate the effects of an attack. These can include cameras, bollards, armed guards, etc.) (Note: These should be coded according to standard defensive measures employed against terrorist attacks at the date which is being coded.)	To what degree does the new technology / weapon allow the actor to overcome defensive countermeasures?	The technology / weapon does not perform well against extant defensive countermeasures.	Low	0 %	Overcomes countermeasures that might restrict how certain equipment is purchased, which could potentially be useful in obtaining equipment that might be monitored/controlled.
110		The technology / weapon can overcome some but not all extant defensive countermeasures.	Medium	50 %		
111		The technology / weapon can overcome most or all extant defensive countermeasures.	High	50 %		
112					100 %	

114	Existence of Alternatives To what extent do alternative technologies exist that would have the same or similar tactical benefits as the candidate technology?	There are no real alternatives.	None	0 %	Buying non-used lab equipment.	
115		There is a single alternative.	One	0 %		
116		There is more than one alternative.	Some	100 %		
117					100 %	

120 **Availability Characteristics**

121

122	Availability of Information How available is the technical information related to the production and use of the technology? (Note: This information must fully allow a perpetrator to produce and use the technology. Such information would include an online manual or hardcopy textbook that details	The most protected technical information; it is only available through a very limited circulation and is not available otherwise. This would include specialists who have access to the information based on their very specific occupation, i.e. working as a nuclear weapons specialist in the military in a classified environment.	Actively restricted	0 %	Depends on the equipment. Some equipment might be very easy to find info on (e.g. beakers, flasks, condensers), but more complex equipment used in advanced labs is likely to have more limited public documentation.
123					

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T-TAM Domestic Decision Sub-Model Sample Calculation

31	Specialized R&D	1	2	1
32	Centralization	1	0	
33	Spatial Proximity of Organization Elements			
34				
35	Actor Decision Making Characteristics			
36	Risk Tolerance	4		
37	Risk Tolerance Impact		0.75	0.75
38	Determination			
39	Perception of Urgency	1	0	0
40	Decision Maker Attitude to Innovation	3	1	1
41	Centralization Boost	1	0.5	0.5
42	Decision Maker Affinity for Weapon/Technology	0	0	0
43	Internal Champion	1	1	1
44	Guardians of the Status Quo	1	0	0
45	Knowledge Institutionalization	1	0	0
46	Penchant for Improvement	2	0	0
47	Cognitive and Related Bias 1	0		
48	Cognitive and Related Bias 2	0		
49	Cognitive and Related Bias 3	0		
50	Overall Cognitive Bias Effect		0	0
51	Desire for Prestige / Self-Glorification	0	0	0
52	Follow-The-Leader Bias	1	1.5	1.5
53				
54	Actor Strategic Characteristics			
55	Active Searching (General)	1	1	1
56	Active Searching (Technology Type)	0	0	0
57	Ideological/Cultural Incompatibility (Technology Type)	0		
58	Ideological/Cultural Incompatibility - Degree (Technology Type)	0	0	0
59	Innovation Without Conscious Intention	0	0	0
60	Disruption to Organization (Technology Type)	0	0	0
61	Rivalry With Other VNSA(s)	2	1	1
62	Escalatory Pressures: Countermeasures	1	2	2
63	Escalatory Pressures: Overcome Desensitized Audience	0	0	0
64	Lethality Desired	5		
65	Lethality Provided (Status Quo)	3		
66	Safety Desired	2		

	Group / Cell / LA
Risk Tolerance	1.5
"Adoption Riskiness" Modifier	0.5

Development Cycle Length	1
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Cognitive Bias 1 Effect:	0
Cognitive Bias 2 Effect:	0
Cognitive Bias 3 Effect:	0

If group has low centralization, less of an effect: -1; AND/OR if group is highly cohesive, then no effect. If moderately cohesive, -1...		
Cohesiveness (Co) (N/A for lone actors)	Very Low	1
	Low	2
	Moderate	3 If D=1 and Ce = 3, then -1;
	High	4 if D=1 AND Co = 4, then 0
Centralization (Ce) (N/A for lone actor)	Highly Centralize	1 if D=1 AND Ce = 3 AND Co = 3, then = 0
	Somewhat Decen	2 otherwise, if D=1, -2
	Extremely Decen	3 else 0

If D=1 and Central = 3, then 0; if D=1 AND Co = 4, then 0; if D=1 AND CO = 3, then -1; if D=1 AND Ce = 3 AND Co = 3, then = 0, otherwise

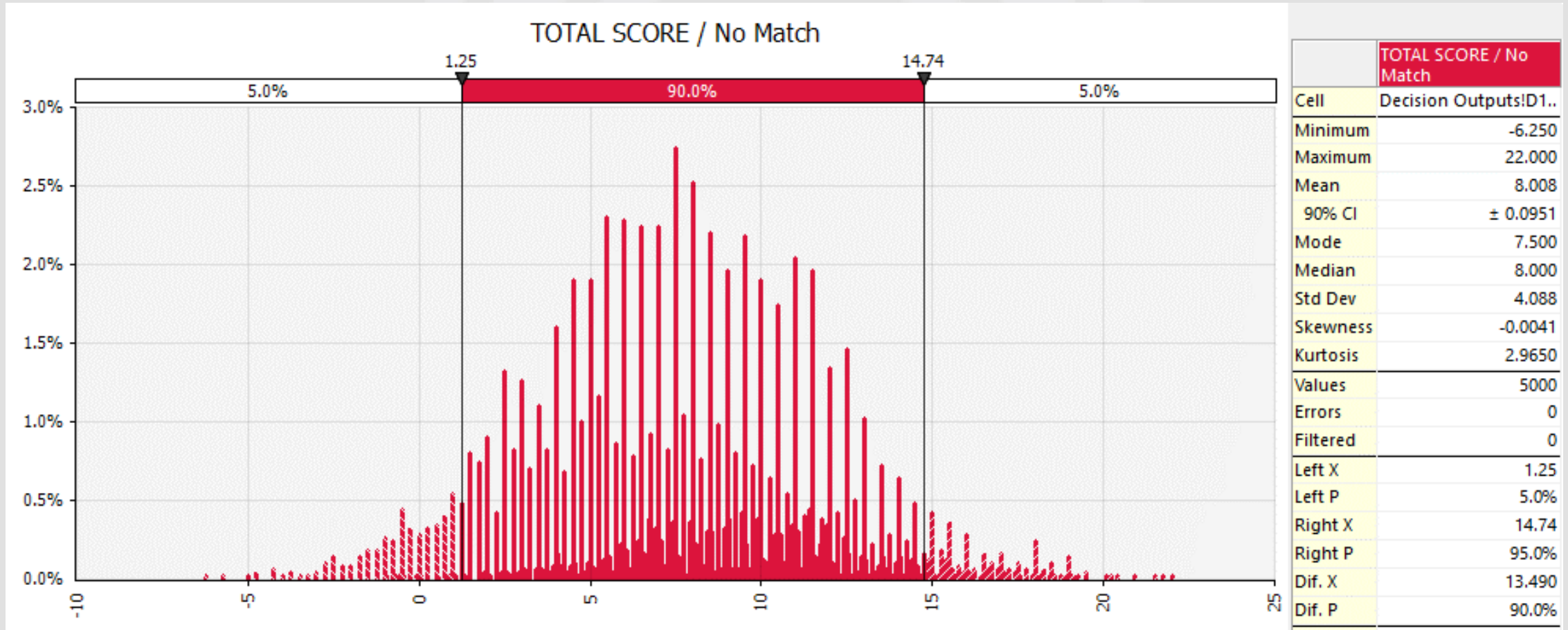
	Group / Cell / LA
Lethality Desired Effect	5
Lethality Provided Effect	3
Safety Desired Effect	2

Change wording of guardian status quo variabl

Change wording on Cognitive Biases to: Moder

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T-TAM Domestic Decision Sub-Model Sample Output



Year 1 Pilot

In order to demonstrate the potential utility of the tool, a **pilot application** was conducted on an illustrative sample of terrorist actors and emerging technologies.

Primary objectives of the pilot were:

- *To verify that the tool **operates** as envisioned and is **capable of providing differential assessments across a variety of actors and technologies.***
- *To assess the **usage** requirements and overall **functionality** of the tool.*

Year 1 Pilot Actors

Final List of Actors:

- ✓ The **Oathkeepers** as a formal, albeit diffuse, organization.
- ✓ An operational cell of the **Lebanese Hizballah**.
- ✓ An **ISIS-inspired autonomous cell of HVEs** (with no operational connection to the main ISIS group or any of its affiliates).
- ✓ A **lone actor** motivated by the **far-right ideas of Accelerationism**
- ✓ A **lone actor** motivated by grievances associated with the **Incel movement**

Year 1 Pilot Technologies

Final List of Technologies:

- ✓ **Artificial Intelligence / Machine Learning** used to provide new pathways for chemical weapons production.
- ✓ **3D Printing** utilized to produce sprayers capable of disseminating biological weapons.
- ✓ **Pharmaceutical-Based Agents** (primarily fentanyl and its analogs).
- ✓ **Toxin Synthesis**, i.e., the ability to synthesize a new or rare toxin from scratch.
- ✓ **Second Hand Chemical Production Equipment**

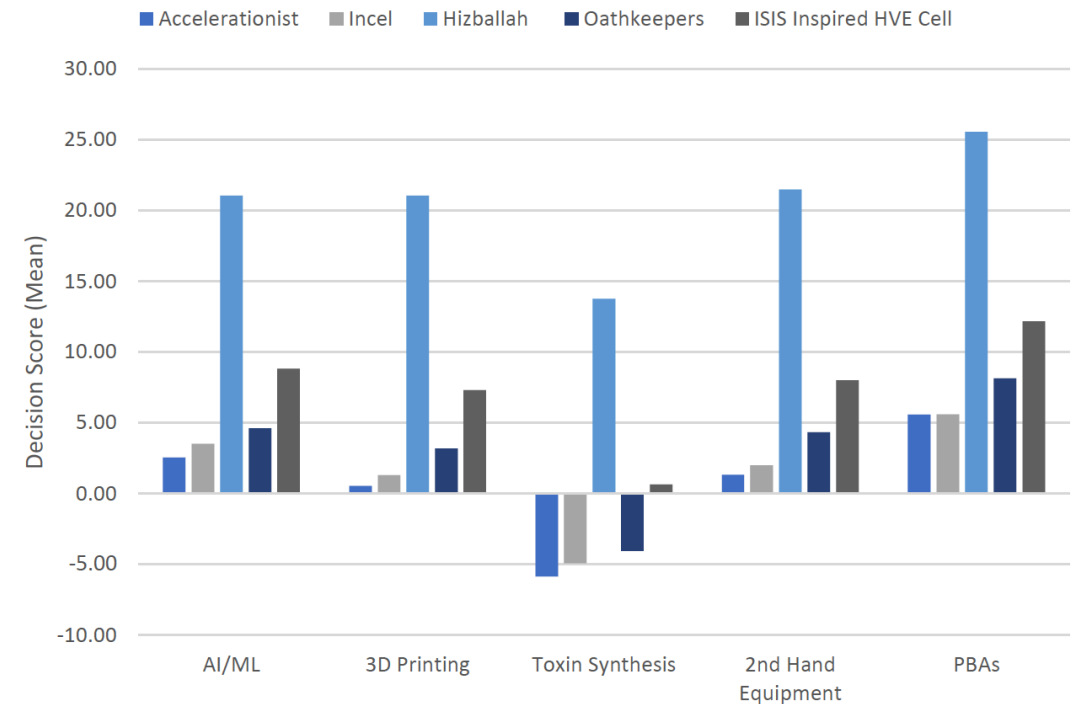
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YEAR 1 Pilot – Adoption Decision

Table 1: T-TAM Decision Output Scores for Pilot Run

Actor Type	Lone Actor		Group		Cell
Actor	Accelerationist	Incel	Hizballah	Oathkeepers	ISIS Inspired HVE Cell
AI/ ML					
Mean	2.55	3.50	21.05	4.61	8.83
StdDev	3.72	3.99	3.50	3.42	4.03
3D Printing					
Mean	0.54	1.31	21.05	3.18	7.30
StdDev	3.30	3.40	3.42	3.02	3.74
Toxin Synthesis					
Mean	-5.86	-4.92	13.76	-4.06	0.65
StdDev	4.32	5.04	3.65	3.87	4.56
2nd Hand Equipment					
Mean	1.32	1.99	21.50	4.33	8.01
StdDev	3.88	4.21	3.48	3.43	4.09
PBAs					
Mean	5.58	5.61	25.57	8.13	12.18
StdDev	3.51	3.67	3.29	3.10	3.79

Figure 1: Decision Model by Actor



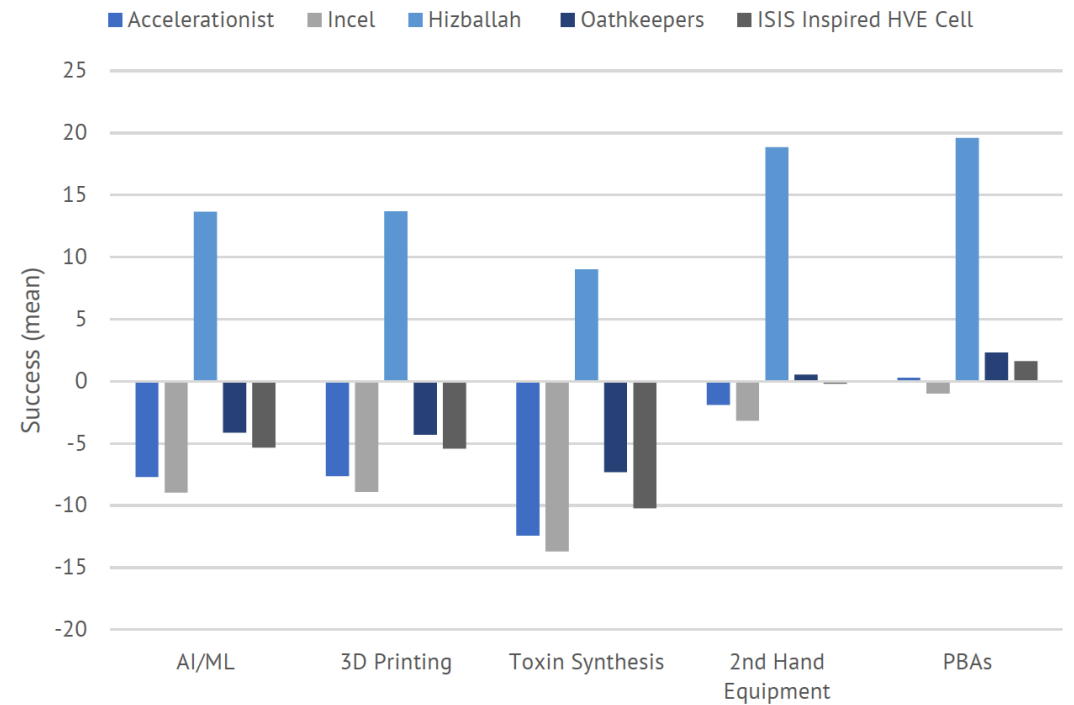
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YEAR 1 Pilot – Adoption Decision

Table 2: T-TAM Success Output Scores for Pilot Run

Actor Type	Lone Actor		Group		Cell
	Accelerationist	Incel	Hizballah	Oathkeepers	ISIS Inspired HVE Cell
AI/ML					
Mean	-7.70	-8.95	13.67	-4.14	-5.33
StdDev	2.40	2.13	2.94	2.42	2.54
3D Printing					
Mean	-7.63	-8.89	13.68	-4.30	-5.43
StdDev	2.88	2.61	2.92	2.66	2.82
Toxin Synthesis					
Mean	-12.44	-13.69	9.01	-7.32	-10.21
StdDev	3.07	2.85	2.79	2.64	3.08
2nd Hand Equipment					
Mean	-1.91	-3.16	18.84	0.54	-0.19
StdDev	3.45	3.26	3.25	2.86	3.27
PBAs					
Mean	0.29	-0.99	19.58	2.32	1.62
StdDev	2.66	2.46	3.07	2.55	2.91

Figure 4: Success Model by Technology



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Applications

TTAM / (D)
Tool

- ✓ Mitigates both over- and under-reaction to emerging technology threat
- ✓ Moves from assessing theoretical potential of emerging technologies to “real world” terrorist threat against the Homeland.
- ✓ Eventual tool will be easily updated and re-run with new data, technologies, adversaries => “building libraries”
- ✓ Provides HSE stakeholders with a **sustainable** capability.

Year 2 Tool Development

- Current tool is “**lab-use**” **only** and not designed for usability or HSE workflows
- We are ***developing user-friendly interfaces*** and ***operational processes*** that maximize usage by HSE analysis and stakeholders
- Need input from DHS end-users: *In Spring 2024, worked with I&A analysts on a series of usability surveys.*
- *Fully functioning prototype by Fall 2024.*

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