Scripting the Terror Contagion Hypothesis Supplementary Materials

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1 Simulation Documentation

The Terror Contagion Simulation is completely documented in over 300 pages, covering the structure, equations, confidence-building measures, contingency analysis results, and data, including the behavior modes of over 4,600 terror incidents. This full documentation can be found associated with our prior open-source peer-reviewed publications[1] and can downloaded from this link:

https://incose.onlinelibrary.wiley.com/action/downloadSupplement?doi=10.1002%2Fsys.21743&file=sys21743-sup-0001-SuppMat.pdf

In this supplemental, we provide additional information specifically relevant to this article

1.1 Terror Contagion Simulation

The simulation runs for ten years to explore the terror contagions that can spawn from this seed event. Each simulation imports a file of contagion settings to initialize key values. Contagion settings consist of the initial stock and parameter values of either a generic or researched violent ideology, including success rates and average fatality rates of template methods, factors related to the high-risk population, and the extent to which this violent ideology is or is not supported by non-state actors operating in a safe haven. Contagion settings also contain policy response options activated as switches to test policy responses against a specific violent ideology. In this paper, at the higher level of abstraction, we limit the contagion settings to the following elements:

1. Seed Event Time
2. Seed Event Fatalities
3. Out the Door Success Rate
4. After Seed Event Average Template Fatalities

5. After Seed Event Standard Deviation of Template Fatalities
6. After Seed Event Minimum Fatalities of a Completed Event
7. After Seed Event Maximum Fatalities of a Completed Event
8. Pathway to Violence Success Rate

The final item, Pathway to Violence, is the success rate with which a perpetrator conducts their planning and preparations to the point they can start an incident by going “out the door”, at which point the OTD success rate is used. In prior research, we identified four common behavior modes reflective of a pathway to violence success rate described below:

1. Equilibrium (EQ) = NA as there is no Seed Event and thus no Contagion
2. Failure to Grow (F2G) = 10%
3. Struggle to Grow (S2G) = 20%
4. Contagion (CONT) = 50%
5. Strong Contagion (CONT+) = 100%

Figure 1 depicts an aggregate view of the Terror Contagion Simulation “core model,” which contains five system levels: Incidents (1), Agents (2), Networks & Actors (3), System of Spaces (4), and System of Systems (5). Each level represents one layer of the system's structure within which key dynamics occur. The arrows in Figure 1 represent the upward and downward causation of these causal influences crossing between system layers. Modules containing model documentation, model values, and testing structure are excluded from this depiction for clarity.

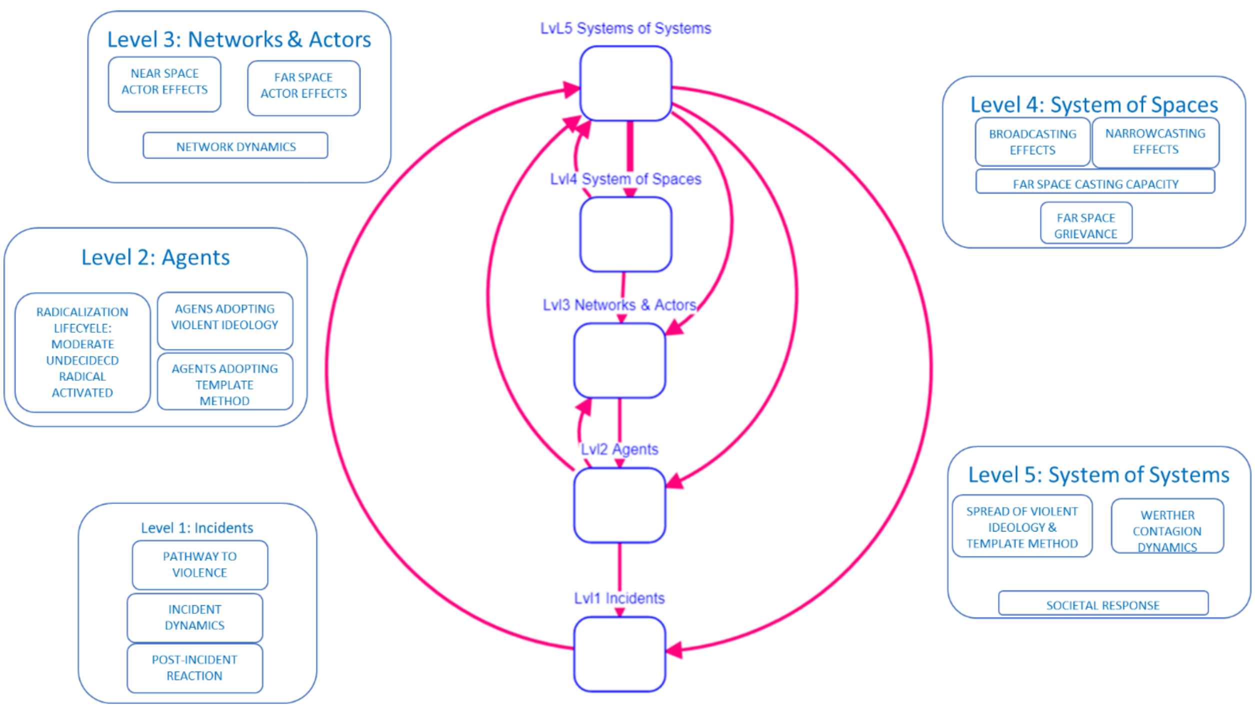


Figure 1 Overview System Structure Levels & Sectors of Terror Contagion Hypothesis Model

The four baseline runs of the simulation include equilibrium (EQ), failure to grow (F2G), struggle to grow (S2G), contagion (CONT), and strong contagion (CONT+) manifestations.

1.2 Settings

Table 1: Contagion Settings for Initial Values for Historical & Experimental Runs

Simulation Run	ModVal. Seed Time (Month)	ModVal.Template Method Success Rate (OTD)	Seed Event Fatalities	Mean After Seed Fatalities	SD After Seed Fatalities	Random Seed	After Seed Min	After Seed Max	ModVal.Pathway to Violence Success Rate
CSS Historical	4	1	13.0	5.1	7.0	7.0	0.0	33.0	S2G 20%
VA Tech Historical	7	84%	33.0	13.8	13.9	7.0	0.0	34.0	CONT 50%
INCEL Historical	5	84%	6 *	5.7	5.5	7	0	17	CONT 50%

*See note in Results for variance between Historical Seed Fatalities (6) and entered Seed Fatalities (13)in the simulation for Incel to account for low-fatality seed events. Note on all reports the actual historical fatalities (6) are used.

Table 2: Template Attractiveness Settings for all Simulation Runs

Contagion	Self-Similarity	Notoriety	Coherence
CSS Historical	1	1	1
VA-Tech Historical	.5	.5	.5
GWRT Historical	1	1	1
Incel Historical	1	.75	1

1.3 Forecasting Accuracy

Our data is reported in 1-month increments over ten years or 120 months for forecasting performance measurements. Because we focus on the long-term behavior of contagions over time, we are not concerned with point-to-point accuracy month-to-month. Instead, we used a rolling 12-month average beginning in the first month of the 2nd year of the simulation. This phrases the question of confidence: "Within a given 12-month period, how accurate is our simulation compared to the historical record?" We calculated the Mean Average Error (MAE) and Means Squared Error (MSE) from this. We then further decomposed MSE using Theil's Inequality statistics. A prevalence of MSE attributable to U^c indicates covariance, meaning the model captures the means and the trends well, but data may be different point by point[2, pp. 875–880].

As our simulations run over ten years, the month-to-month accuracy of any single incident is less important than the overall behavior reproduction. So, the high U^c and low MSE build confidence in the ability of the simulation to reproduce historical behavior, which becomes the basis for building confidence in the experiments and counterfactuals. These are dimensional specific, so Incident MAE reflects the error in completed incidents, and MAE Fatalities reflects the error in deaths. For behavior-over-time reproduction, we faced a challenge because of how infrequently completed public mass killing terrorist events are, often with years going by without a replication. This caused difficulty as many month values were "0," and there is not a regular value reported for that period as there might be in other forecasting of more frequent behaviors (e.g., daily values of the NASDAQ.) This is reflected in Theil's Inequality statistics, which decompose the Mean Squared Error (MSE) into three categories: U^m, U^s, U^c. If most MSE occurs in $U^{m,}$ this reflects a systemic bias. A prevalence of MSE attributable to U^s conveys a problem of unequal variation, that the simulation and historical record have different trends. Either indicates potential fundamental problems with the model.

2 CSS Findings Supplemental

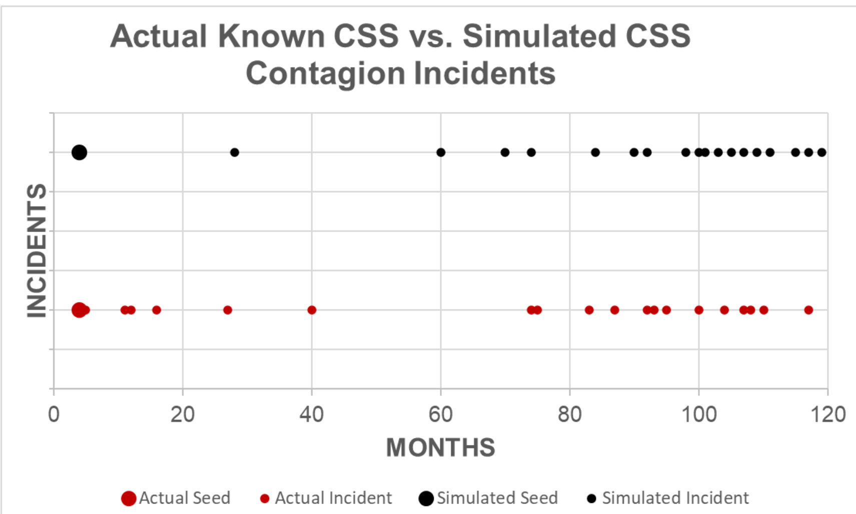


Figure 2: Comparison Plot of Actual Historical vs. Simulated CSS Historical Contagion

3 VA Tech Findings

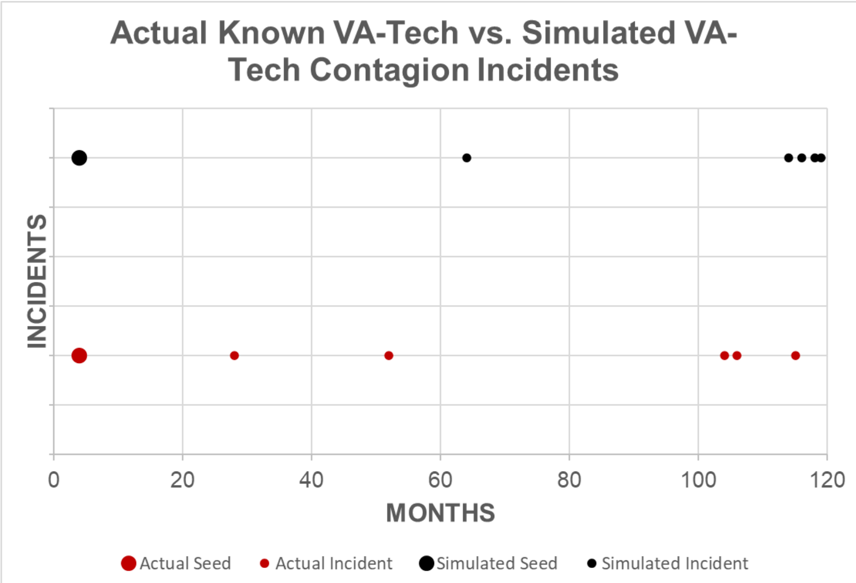
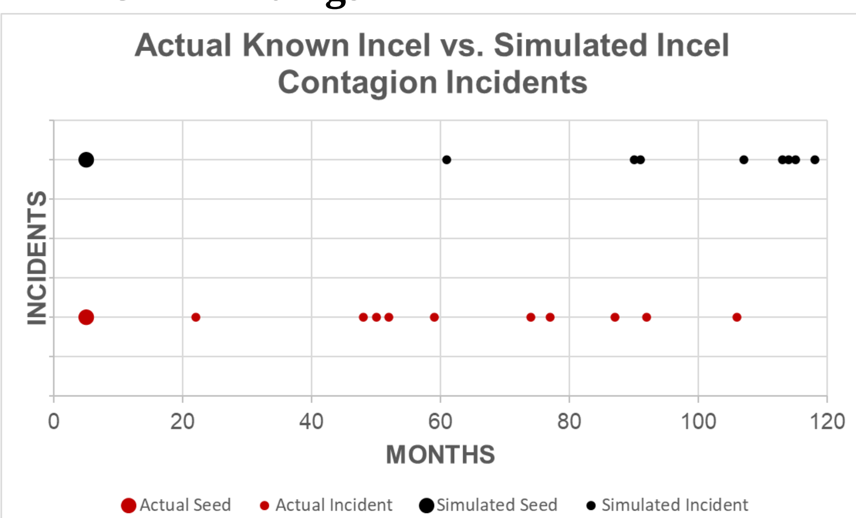


Figure 3: Comparison Plot of Actual Historical vs. Simulated VA-Tech Contagion

4 INCEL Findings



5 Suspected Terror Contagion Data Set

Below are the 41 suspected terror contagion data sets that fit the criteria of occurring between 1995-2022, resulting in 4+ victim fatalities and occurring in the United States. In the below table TVP ID is the ID for the Violence Project data set. Primary and secondary contagions are listings of the contagion influences we found. Although listed as primary and secondary, they do not at this time indicate a higher or lesser prevalence of influence, just that more than one contagion influenced that incident.

TCS ID	Date ID	TVP ID	Full Date	Perperator	City	State	Country	Victim Fatalities	Victim Injuries	Primary Contagion	2nd Addl Cont
19980324	19980324	57,58	3/24/1998	Michael Johnson & Andrew Douglas Golden	Jonesboro	AR	USA	5	10		
19990915	19990915	59	5/21/1998	Kipland Kinkel	Springfield	OR	USA	4	24		
19990420	19990420	71,72	4/20/1999	Dylan Klebold and Eric Harris	Aurora	CO	USA	13	23	CSS	
19990915	19990915	75	9/15/1999	Larry Greene Ashbrook	Fort Worth	TX	USA	7	7		
20050312	20050312	94	3/12/2005	Terry Ratzman	Brookfield	WI	USA	7	4		
20050321	20050321	95	3/21/2005	Jeffrey James Weise	Red Lake	MN	USA	10	5	CSS	
20051002	20051002	100	10/2/2005	Charles Roberts	Bart Township	PA	USA	5	5		
20070415	20070415	102	4/15/2007	Seung-Hui Cho	Blacksburg	VA	USA	33	17	VA-TECH	
20071205	20071205	103	12/5/2007	Robert Arthur Hawkins	Omaha	NE	USA	8	5		
20210315	20071209	104	12/9/2007	Matthew Murray	Arvada	CO	USA	4	5		
20080207	20080207	105	2/7/2008	Charles Thornton	Kirkwood	MO	USA	5	1		
20080214	20080214	106	2/14/2008	Steven Kazmierczak	Dekalb	IL	USA	5	21	CSS	
20090329	20090329	110	3/29/2009	Robert Stewart	Carthage	NC	USA	8	3		
20090403	20090403	111	4/3/2009	Jiverly Antares Wong	Binghamton	NY	USA	13	4	VA-TECH	
20091105	20091105	113	11/5/2009	Nidal Hasan	Fort Hood	TX	USA	13	32		
20110108	20110108	120	1/8/2011	Jared Lee Lougher	Tucson	AZ	USA	5	13		
20120402	20120402	124	4/2/2012	One Goh	Oakland	CA	USA	7	3		
20120530	20120530	125	5/30/2012	Ian Stawicki	Seattle	WA	USA	5	1		
20120720	20120720	125	7/20/2012	James Eagan Holmes	Aurora	CO	USA	12	70		
20120805	20120805	127	8/5/2012	Wade Page	Oak Creek	WI	USA	5	3		
20121214	20121214	129	12/14/2012	Adam Lanza	Newton	CT	USA	27	1	CSS	
20150517	20150517	135	5/23/2014	Elliot Rodger	Isla Vista	CA	USA	5	14	INCEL	VA-TECH
20180518	20180518	147	5/12/2015	Omar Mateen	Orlando	FL	USA	49	53		
20150517	20150517	138	5/17/2015	Dylan Roof	Charleston	SC	USA	9	1		
20151001	20151001	140	10/1/2015	Christopher Harper_mercer	Roseburg	OR	USA	9	8	INCEL	VA-TECH
20151202	20151202	142,143	12/2/2015	Rizwan Farook and Tashfeen Malik	San Bernadino	CA	USA	14	24		
20171001	20171001	154	10/1/2017	Stephen Padock	Las Vegas	NV	USA	50	857		
20180214	20180214	158	2/14/2018	Nikolas Cruz	Parkland	FL	USA	17	17	CSS	INCEL
20180518	20180518	151	5/18/2018	Dimitrios Pagourtzis	Santa Fe	TX	USA	10	13	CSS	
20181027	20181027	154	10/27/2018	Robert Gregory Bowers	Pittsburgh	PA	USA	11	5		
20181107	20181107	155	11/7/2018	David Long	Thousand Oaks	CA	USA	12	21		
20190803	20190803	159	8/3/2019	Patrick Wood Crusius	El Paso	TX	USA	23	25		
20190804	20190804	170	8/4/2019	Connor Stephen Betts	Dayton	OH	USA	9	27		
20191210	20191210	172,173	12/10/2019	David Anderson and Francine Graham	Jersey City	NJ	USA	4	3		
20210315	20210315	177	3/15/2021	Robert Long	Atlanta	GA	USA	8	1	INCEL	
20210322	20210322	178	3/22/2021	Ahmad al Aliwi Alissa	Boulder	CO	USA	10	1		
20211130	20211130	182	11/30/2021	Ethan Crumbley	Oxford Township	MI	USA	4	7		
20220514	20220514	184	5/14/2022	Payton Gendron	Buffalo	NY	USA	10	3		
20220524	20220524	185	5/24/2022	Salvador Ramos	Uvalde	TX	USA	21	17	CSS	
20220704	20220704	187	7/4/2022	Robert Crimo	Highland Park	IL	USA	7	45		
20221119	20221119	189	11/19/2022	Anderson Aldrich	Colorado Springs	CO	USA	5	19		

6 Supplementary Sources

[1] T. Clancy, B. Addison, O. Pavlov, E. Palmer, and K. Saeed, "Systemic innovation for countering violent radicalization: Systems engineering in a policy context," *Systems Engineering*, p. sys.21743, Jan. 2024, doi: 10.1002/sys.21743.

[2] J. Sterman, *Business dynamics: systems thinking and modeling for a complex world*. Boston: Irwin/McGraw-Hill, 2000.