Making Agent Fate Data Useful to the Warfighter

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Objective

The goal of this effort is to accelerate delivery of agent fate results of high operational impact to the Warfighter by leveraging existing scientific data to resolve key conflicts, gaps, and uncertainties as defined by Warfighter needs and payoffs, enabling the prioritization of current and future agent fate products by operational payoffs versus research cost.

Background and Significance

Despite the investment in agent fate experiments over several decades, agent fate estimates used for operations have not improved in large part since the 1990s. Historically, conflicts and inconsistencies existed in the guidance and focused delivery to end users lagged in time. The timing is perfect to improve delivery of agent fate results, as the operational guidance is currently being updated and the Chemical Biological Effects Manual 1 (CB1) is beginning production.

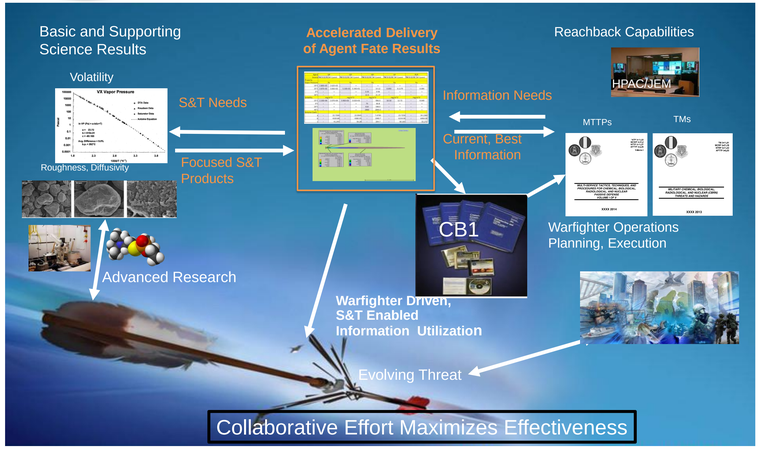
Benefits

This research will benefit not only the Warfighter, but also various organizations that rely on agent fate information. An immediate benefit of the work will be to resolve longstanding operational guidance conflicts, inconsistencies, and gaps, using existing data, and produce results needed by Warfighters immediately for traditional agents and enable non-traditional agent (NTA) hazard estimates. An operations informed analysis allows prioritization of agent fate work based on that work which gives highest payoffs, and does so by leveraging the science and technology (S&T) base for greatest Warfighter impact and focusing future efforts on meeting specific Warfighter needs.

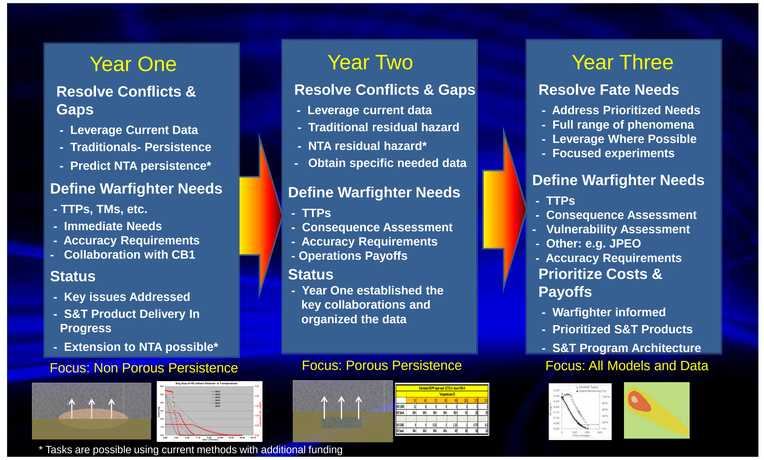
Description of Effort

1) Deliver the most current agent fate S&T products to the Warfighter and Chemical Biological Defense community
   - Identify and resolve conflicts & gaps in operational guidance
   - Leverage most current agent fate data and models
   - Predict NTA persistence based on physical properties
2) Put the right S&T products in the right places
   - Assure operational documents contain correct information at the right level of detail
   - Assure CB1 contains the most current, best, agent fate information at the highest appropriate detail

Big Picture



Project Lifecycle

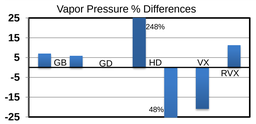


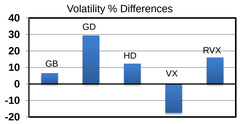
* Tasks are possible using current methods with additional funding

Examples of Suggested Publication Updates

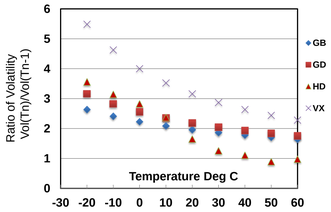
Vapor Pressure and Volatility

Agent	GB		GD		HD		VX		RVX	
Source	TM 3-11.91	AF Current	TM 3-11.91	AF Current	TM 3-11.91	AF Current	TM 3-11.91	AF Current	TM 3-11.91	AF Current
Property										
Vapor Pressure	Pa		Pa		Pa		Pa		Pa	
20° C	2.80E+02	2.62E+02	-	+	-	+	-	+	-	+
25° C	3.87E+02	3.66E+02	5.33E+01	5.34E+01	-	14.12	0.093	0.1179	-	0.084
0° C	-	+	-	+	3.33	0.96	-	+	-	+
30° C	-	+	-	+	12.0	21.37	-	+	-	+
Volatility	mg/m^3		mg/m^3		mg/m^3		mg/m^3		mg/m^3	
25° C	2.20E+04	2.07E+04	3.90E+03	3.02E+03	-	906.0	10.50	12.72	-	9.049
0° C	-	+	-	+	75	66.8	-	+	-	+
20° C	-	+	-	+	610	598.0	-	+	-	+
40° C	-	+	-	+	2860	2840.0	-	+	-	+
Antoine Coefs					+	+				
a	-	22.7200	-	22.0945	-	7.4749	-	23.7250	-	24.1360
b	-	4320.80	-	4382.05	-	1940.7	-	6154.90	-	6464.00
c	-	41.245	-	56.28	-	204.7	-	60.165	-	55.271





Evaporation Rate Change with Temperature



Excerpt from ATP 3-11.32:
Temperature: High Temperatures speed up the change of state for liquid vapor (evaporation) and hasten the dispersion of chemical agents in the air. The persistency of the liquid chemical agents decreases as the temperature increases. Because the chemical warfare agent evaporation rate approximately doubles with each 100C increase in temperature, and because evaporation increases an average of approximately 25 percent with each 1 meter per second wind speed, the blowing of hot winds over chemical agent-contaminated areas should hasten the weathering process

Hazard Duration

Current ATP45 type B case

Table E-4. Type B Attack, Probable Time After Ground Contamination at Which Personnel May Safely Remove Protective Masks

Daily Mean Surface Air Temperature	Within Attack Area (Number of days)	Within Hazard Area (Number of Days)
< 10° C	3–10 days	2–6 days
11°–20° C	2–4 days	1–2 days
> 20° C	up to 2 days	up to 1 day

What if we used "the latest" to update this:

At Target Edge - 250 Kg on 3ha target

Temperature °C	TVX days	VX days	THD days	HD days	TGD days	GD days
-10	6500	2428	88.3	8.12	14.34	1.82
0	1811	72.1	26.0	2.34	5.96	0.72
10	569	23.4	8.3	0.73	2.72	0.31
20	198	8.3	3.4	0.30	1.33	0.14
30	75	3.2	1.6	0.14	0.68	0.07
40	31	1.4	0.8	0.07	0.37	0.04
50	14	0.6	0.4	0.04	0.22	0.02

At 1km - 250 Kg on 3ha target

Temperature °C	TVX days	VX days	THD days	HD days	TGD days	GD days
-10	816	113.4	17.0	2.85	9.13	1.36
0	588	38.3	6.9	1.00	4.42	0.59
10	259	13.7	2.8	0.36	2.18	0.27
20	111	5.2	1.3	0.16	1.11	0.13
30	50	2.2	0.7	0.08	0.59	0.07
40	23	1.0	0.4	0.04	0.33	0.03
50	11	0.5	0.2	0.03	0.19	0.02

Findings

Physical Properties Affecting Persistence Estimates (in Rough Order of Importance on Persistence)

1) Preparation – thickening impacts drop size; thickening = ~10x duration
2) Temperature dependence of vapor pressure & degradation; -20ºC = ~5-10 x duration, but varies significantly from agent to agent
3) Spread factor / contact angles (= surface tension/viscosity/adhesion); 2x diameter = ~4x shorter duration
4) Wind speed; 2x wind speed = ~2x shorter duration
5) Aging/Degradation; ~ 1.2x shorter duration
6) Preparation - purity (other than thickener and spread factor); ~ +/- 1.1x duration
7) Isomeric variation; Specific to one agent: VX isomer = ~ 1.5x longer duration

Note: This ranking is for hazard durations. For other metrics, such as vapor concentration, challenge levels or casualties, the ranking of these variables will be slightly different.

Recommendations

1) Discuss the following with developers of operational documentation for consideration:
   - Existing agent fate information that is not currently reflected in operational guidance
   - Inconsistencies and issues in guidance, for example:
     - Thickener has a significant impact on hazard duration and does not currently appear to be considered
     - Hazard duration is largely determined by the few largest drop sizes of a release
     - Toxicity model valid for more than ~8hr is needed
2) Establish a process for assessing ongoing agent fate results and incorporating them into documentation and models
3) Use operationally relevant metrics like hazard distance, liquid and vapor challenge levels, and casualty estimates, in addition to the currently used hazard duration, to set priorities

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