IDA

Current Efforts to Improve Chemical Challenge Estimates

Presentation to the 2011 Chemical, Biological, Radiological, Nuclear Survivability Conference

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IDA | The Problem

- An understanding of “how much” chemical challenge US forces might face on the battlefield is a vital input to all aspects of the acquisition process, from applied S&T to the final fielding decision
- There is concern that some values currently in use are
  - Based on an outdated worldview or outdated technical data
  - Not analytically transparent
  - Not standardized or used consistently through different phases of the developmental life or for equipment that will operate in the same environment
  - Single values do not permit adjusting for higher or lower acceptable risk

IDA | Program of "Challenge" Studies

- To address these concerns, the Joint Requirements Office-CBRND has commissioned a series of studies to chemical (and biological) challenge, as measured by deposition (mg/m2), concentration (mg/m3) and by dosage (mg-min/m3)
  - Chemical Challenge (December, 2006)
  - Non-Traditional Agent Challenge (August, 08)
  - Operational Challenge Study (October, 08)
  - CB Planning Scenarios (ongoing)
- The Joint Science and Technology Office also requested an estimate of challenge in terms of liquid and solid aerosols (# particles/m3 by size bin).

IDA | Challenge Studies Increase in Detail

- Chemical Challenge Study: Notionalized target, realistic artillery, missile, bomb attacks with GB, HL, VX, AC, CG, TVX. Challenge distributions based on individual multi-munition attacks.
- Chemical Challenges for Contamination Survivability Analyses: Requested by T&E Executive for the CBDP to characterize challenge levels on vehicles & equipment
- Non-traditional agent study. Subset of above using non-traditional agents.
- Operational Challenge Study: Similar to Chemical Challenge Study but challenge distributions based on multiple attacks based on CAA TAA-15 analyses
- CB Planning Scenario Study: not a challenge study per se, but enable distributions at the entity level in five operational vignettes (32 attacks—10 bio, 22 chemical).

IDA | Challenge study overview

- Characterize the immediate chemical challenge resulting from attacks with traditional CWA delivered by artillery, missiles and aerial bombs to generic targets of predefined size.
- IDA participated in and coordinated with ITF-46.
- Source terms provided by NGIC, some missile inputs from SAIC.
- Quantitative results are derived with VLSTRACK model and post-processing to obtain droplets and HE shell fragment ranges.
- Challenge quantities are deposition, droplets and concentration per unit target area.
- No TICs. No IEDs. Not considering pickup and transfer.
- Droplet impact velocity not evaluated for this study.

Methodology

Setup and modeling

- Attacks are applied time-on-target to targets of predefined size with imperfect delivery accuracy.
  - Artillery applied to forward units ranging in magnitude from single launcher to multiple battalion fires, with traditional firing doctrine.
  - Up to 5 successful missile strikes to rear-area targets.
  - Bombs applied in sorties of up to 16 weapons on rear-area targets.
- Source terms are required to describe the approximate initial state of the cloud or liquid release per agent-munition combination.
- Release and transport modeled with VLSTRACK, using a fixed meteorological prescription (with excursions)
  - Neutral stability, 5 m/s wind
  - Sensitivity to stability category and wind speed for GB cannon
- Artillery fragmentation effects indicated by measuring only contamination presented beyond a serious injury radius
  - Criterion is 50% chance of hit producing serious injury or death.
  - Fragment data for FSU 152mm cannon round, FSU 122mm rocket.

Measures and metrics

- Challenge metric is the *fraction of target area* presenting deposition, droplets (by size or number), concentration and exposure at or above a given level.
  - We report target coverage to nearest percent, or indicate small, finite challenge at less than 1% coverage or '< 1%'.
  - Cross-tabulate surface contamination with droplet size distribution contributing to each deposition level.
  - Exposures accumulated for lesser of one hour or on-target lifetime of hazard, including secondary evaporation.
- Attacks compared by their capacity to challenge the target; i.e. weapon system accuracy, agent fill weight, dissemination efficiency, and number of munitions fired.
  - Same attack has different result depending on target size.
  - Can compare across multiple weapon systems per agent.
- Challenge results are average or expected outcome, not worst case.

Study cases

		GB	VX	HL	AC	CG
FORWARD	Cannon	V,L,M,S	V,L,F,S	V,L,F,S	V	V
	Sm Rocket	V,L	V,L,F	V,L,F	V	
	Lg Rocket	V,L	V,L	V,L	V	
REAR	TBM	V,L	V,L			
	Bombs	V,L		V,L		

Combinations without notation are excluded from the study.

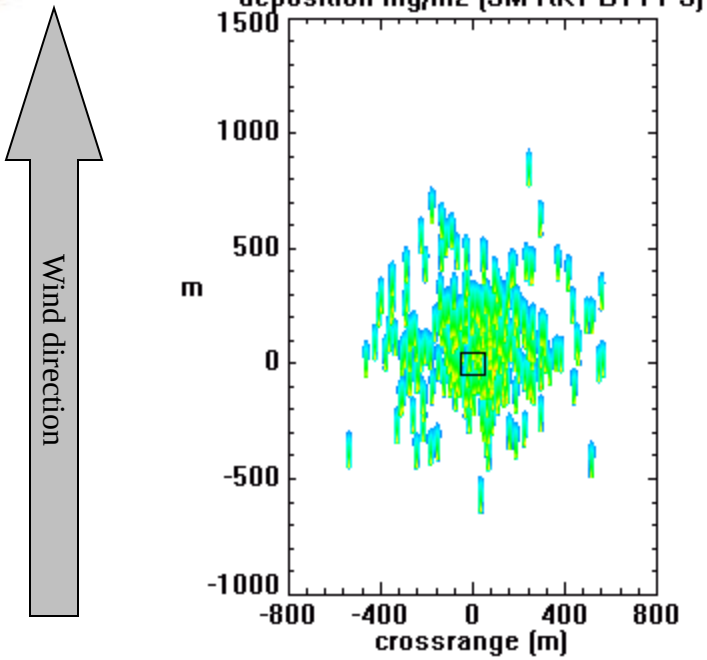
V: vapor measures (*Ct*, C_{max})
L: liquid deposition (including droplets)
F: fragmentation adjusted deposition
M: meteorological excursions
S: standard deviation of mean challenge from munition delivery

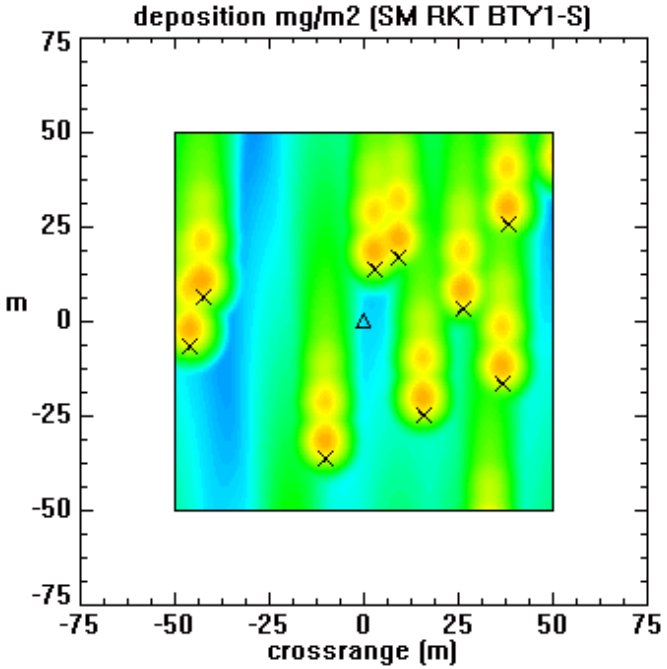
Small (S)	Forward	100 x 100 m^2
Medium (M)	Forward	250 x 250 m^2
Large (L)	Forward, rear*	1000 x 1000 m^2
X-Large (XL)	Rear	4000 x 4000 m^2

*Bomb sorties only to Large target, not TBM

Burst height sensitivity evaluated for artillery with persistent agent fills.

Artillery deposition example

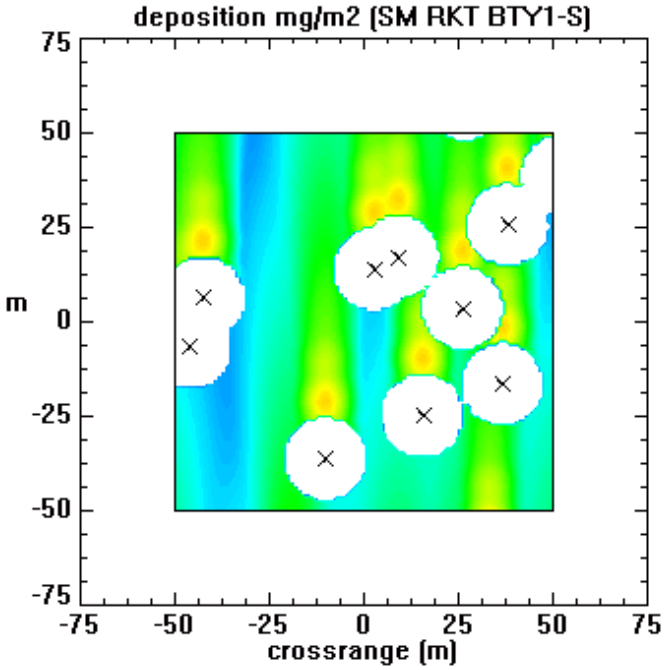


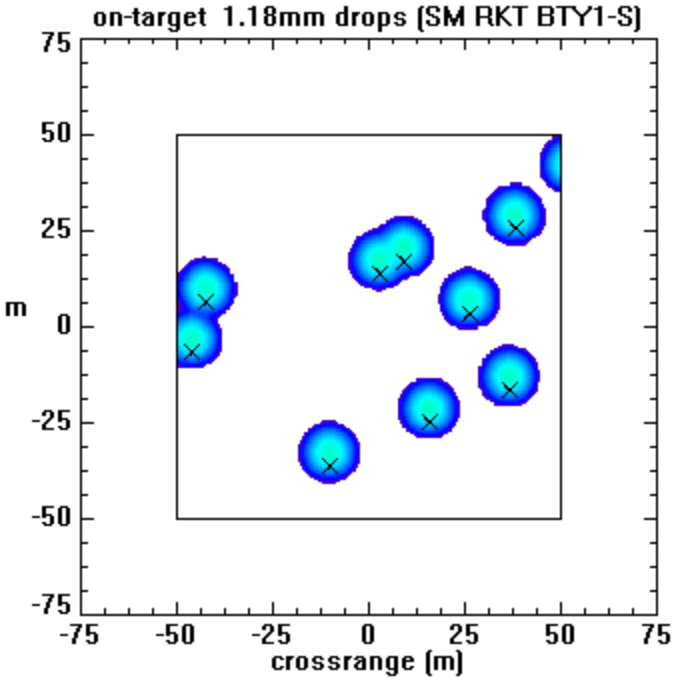


Attack with single battery of small rockets (240) on one hectare target
Only 9 of 240 successfully strike the target

Artillery deposition example

Drops and fragments



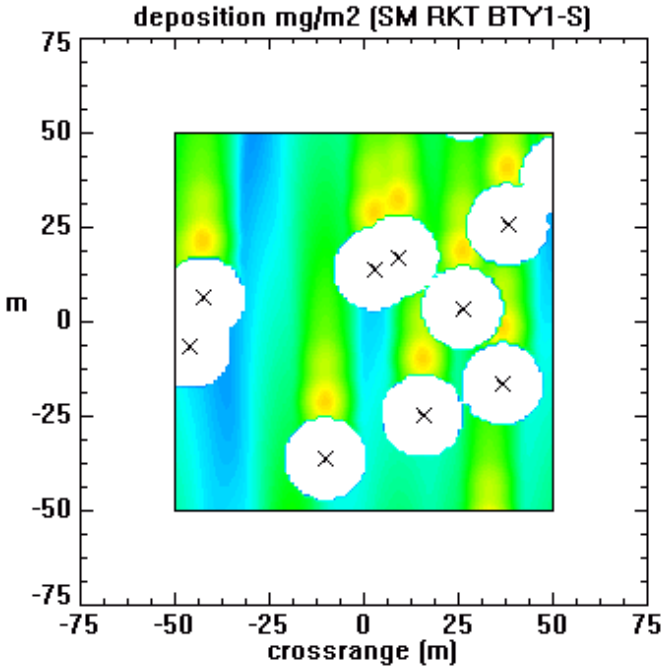


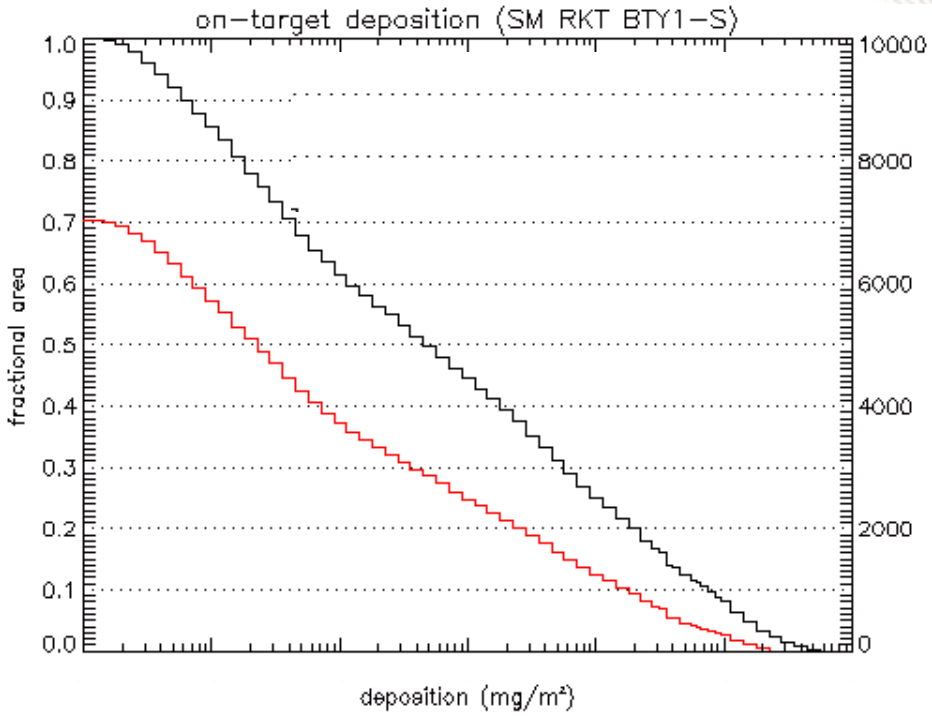
[L] Fragmentation resulting in 50% chance of hit with serious injury to standing unarmored personnel (other postures and protection defined in study)

[R] Distribution of drops with size comparable to TOP 8-2-501 diameter. Note their overlap with fragmentation zones

Artillery deposition example

Adjustment for fragmentation

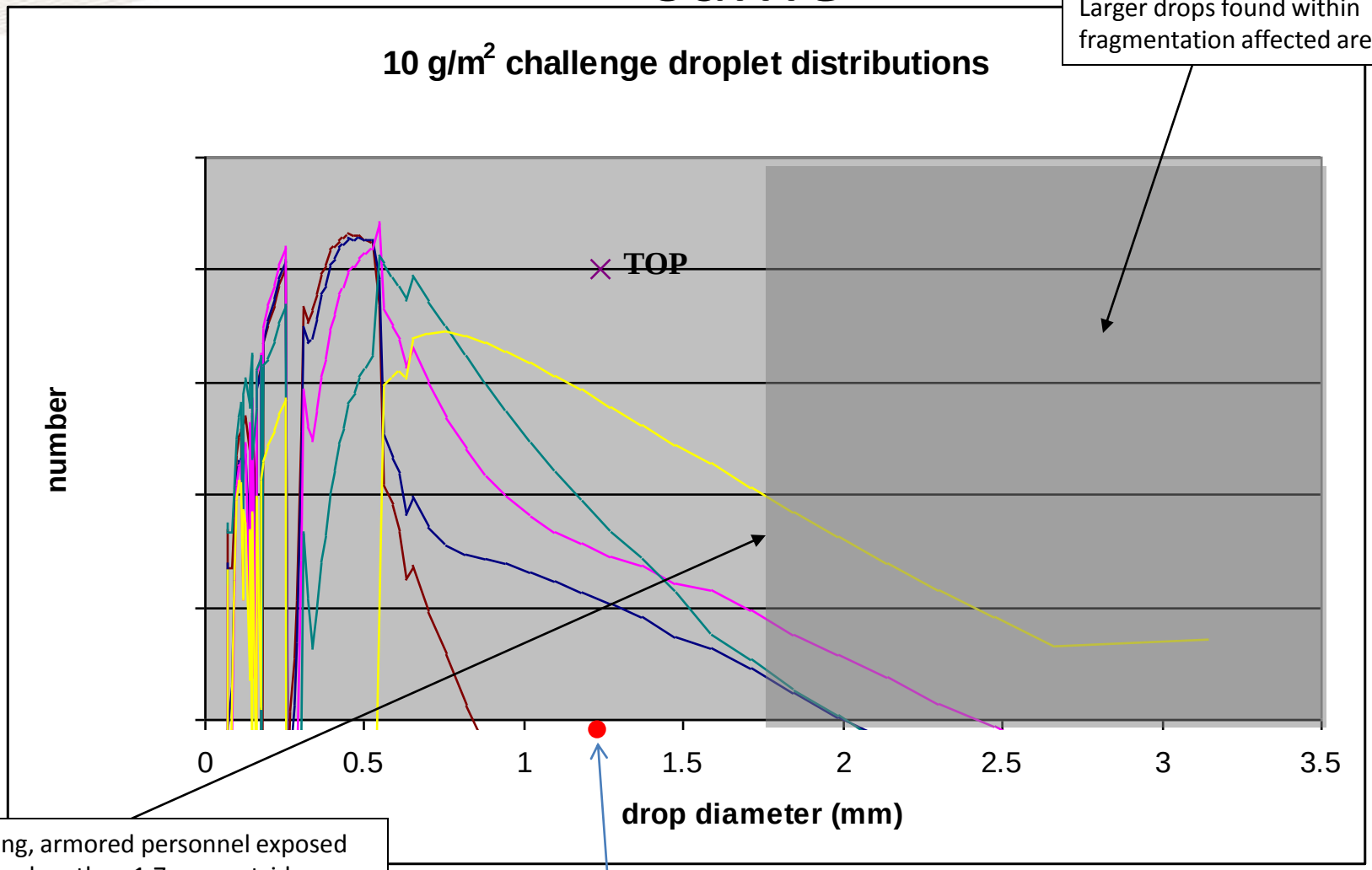




Result is sensitive to protection and posture.

Better ballistic protection → smaller fragmentation circles.

Not all 10 g/m^2 challenges are the same



Larger drops found within fragmentation affected areas.

Standing, armored personnel exposed to drops less than 1.7 mm outside fragmentation range.

Droplet size used in many swatch tests

Study products

- Chemical Challenge Study Report
  - Complete discussion of assumptions and methodology
  - One complete example using graphics
  - Abstracts from full suite of cases
    - Tabulated target coverage at representative deposition, vapor concentrations and exposure levels
- Source Term Database
  - All inputs to VLSTRACK for Challenge Study attacks to facilitate reproduction of results

IDA | Campaign Challenge Calculations

- How do things change if you consider the chemical attacks different units experience over the course of a campaign?
- Using a chemical campaign developed by the Center for Army Analysis for use in the JICM model, we were able to produce campaign-level challenge distributions

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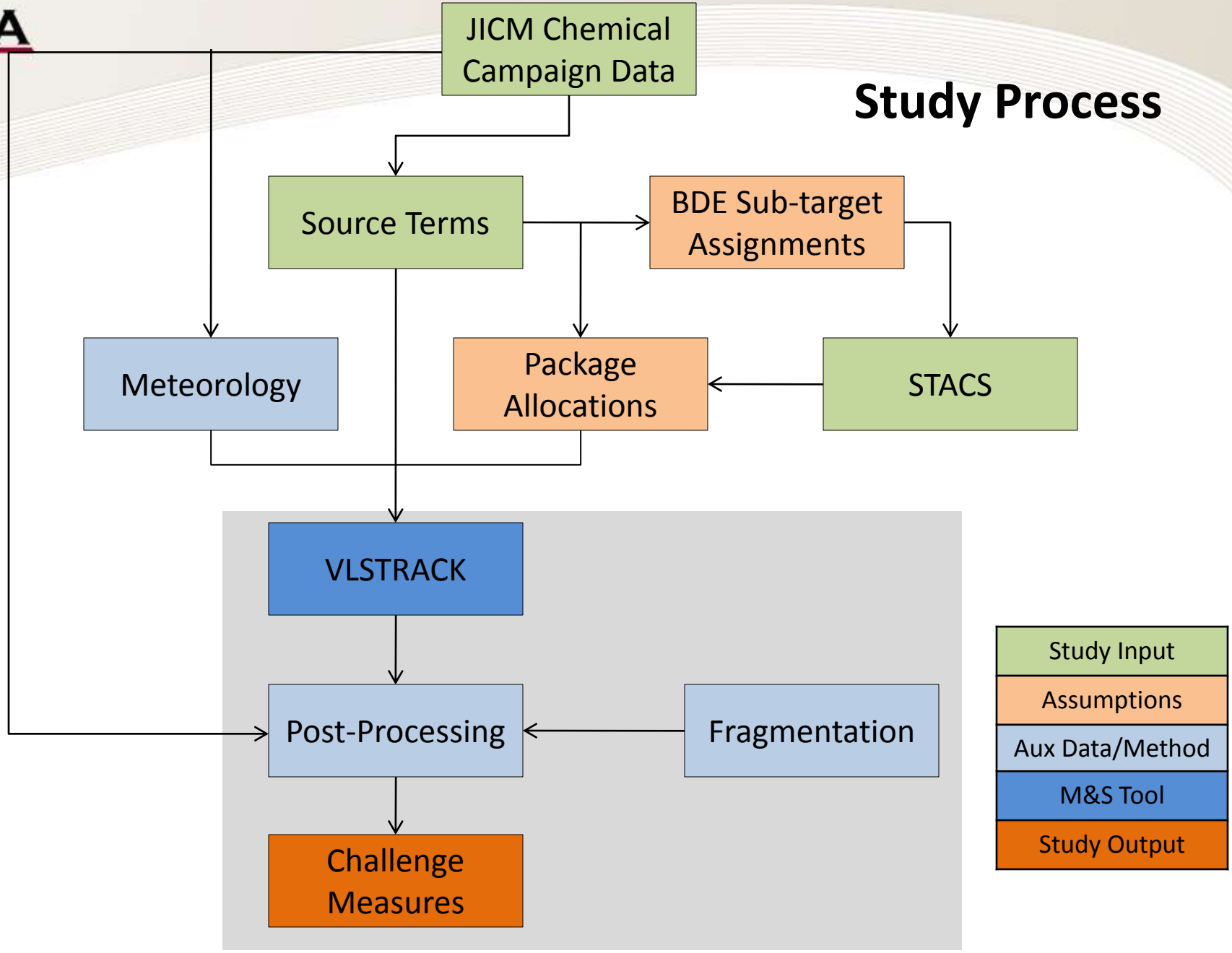
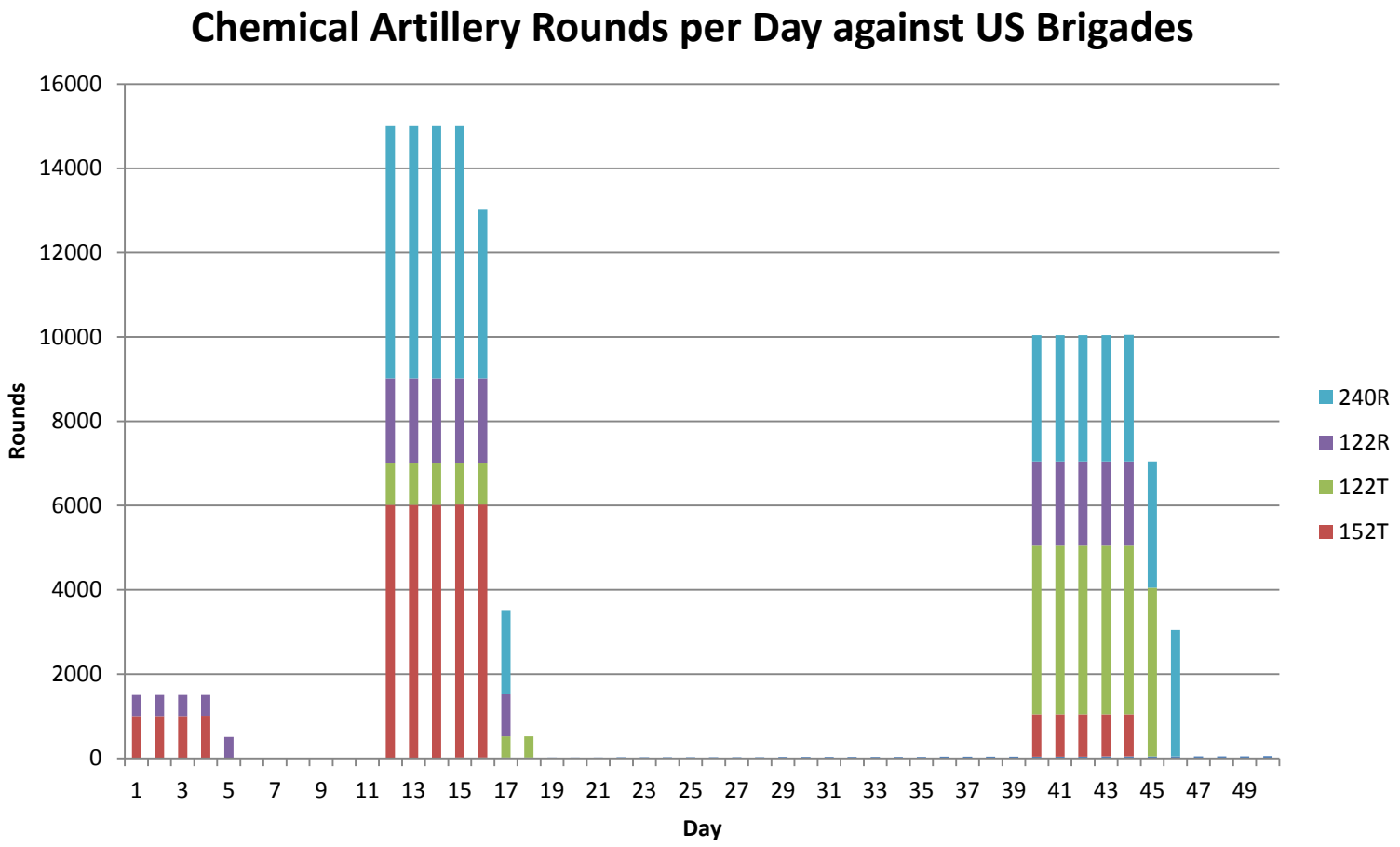
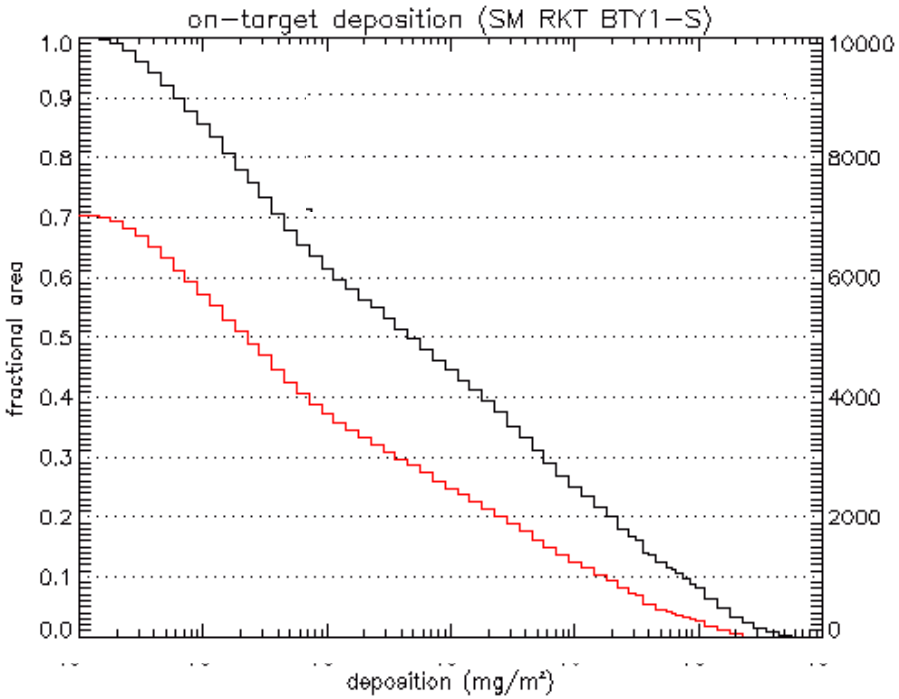
Study Process



Notional Chemical Campaign



- This approach still produces distribution curves such as this, but based on multiple attacks, somewhat different target classes.



IDA | Planning Scenarios Study

- The studies previously discussed used notional targets and measured challenge in terms of area coverage. This does not address what would happen if you consider specific types of entities (aircraft, combat vehicles, buildings, people…)
- Why do that? In many cases, types of entities, such as aircraft, are located near each other and not randomly on an airbase, hence the challenges they face are correlated because they are close together
- The Planning Scenarios study, which develops CB extensions of Defense Planning Scenarios, will also develop entity-level target detail, allowing more detailed examinations of challenges to particular classes of entities
- Entity-level vignettes (snapshots in time) have been developed for APOD, SPOD (with HBCT unloading), HBCT in offense, HBCT in defense)

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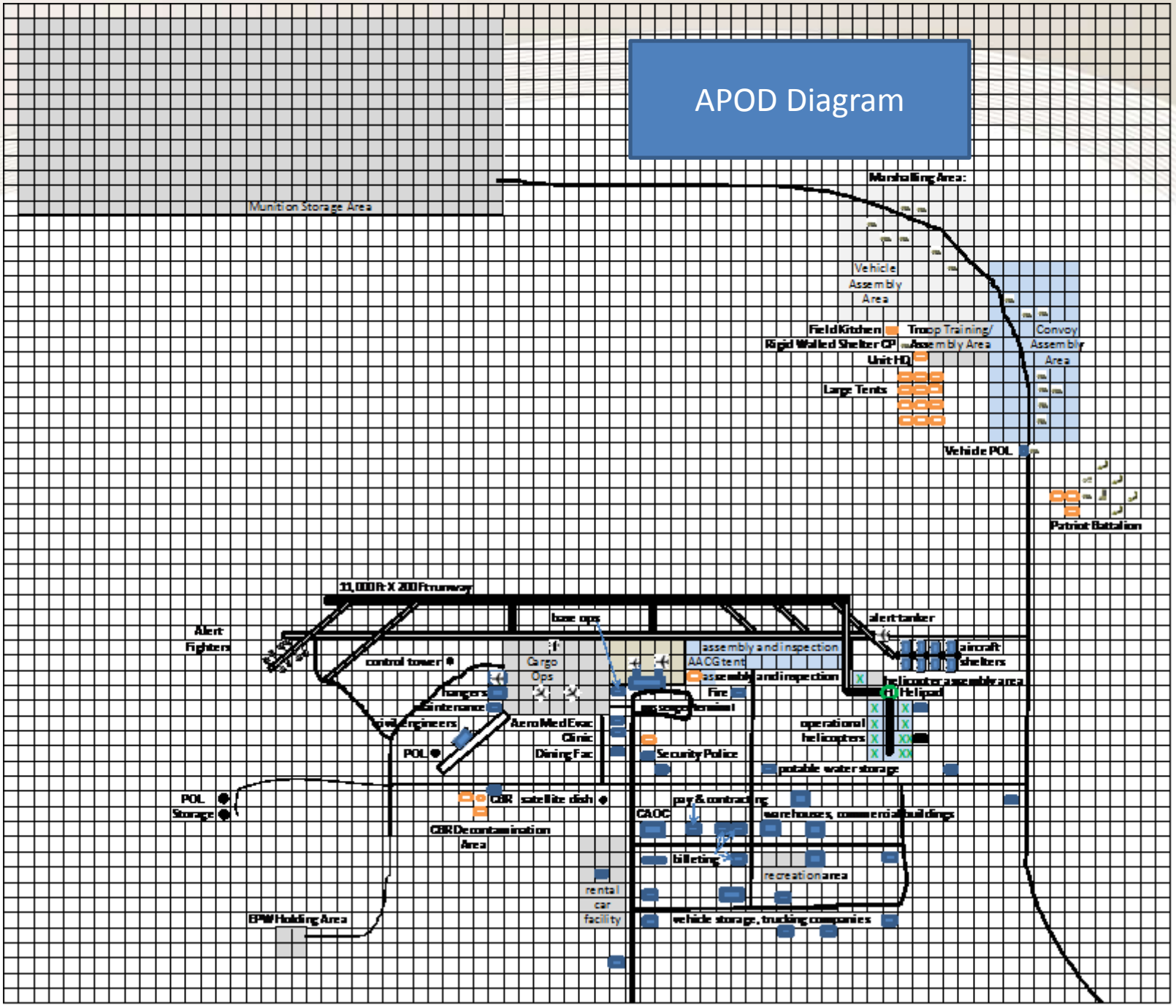
APOD Diagram



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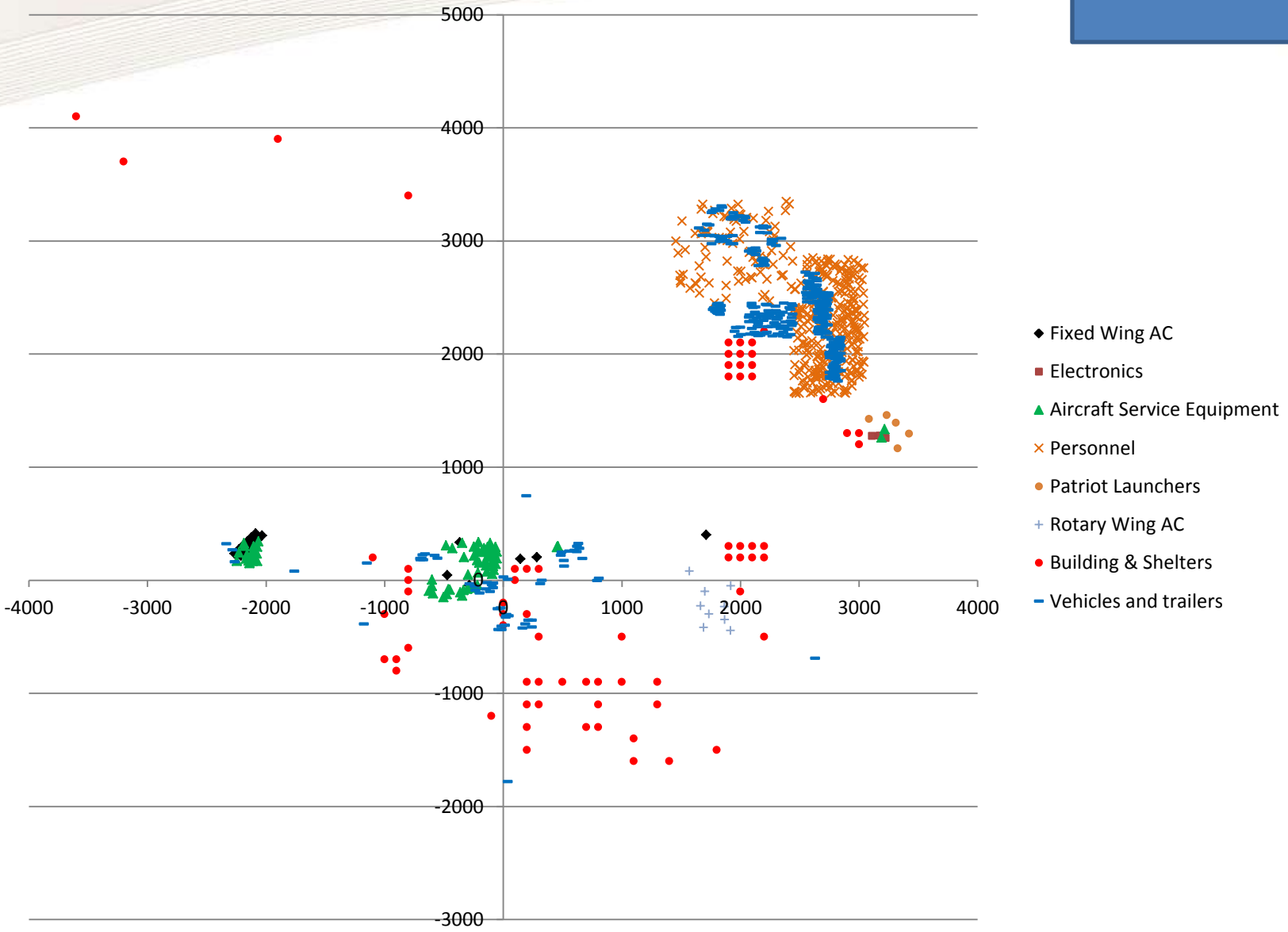
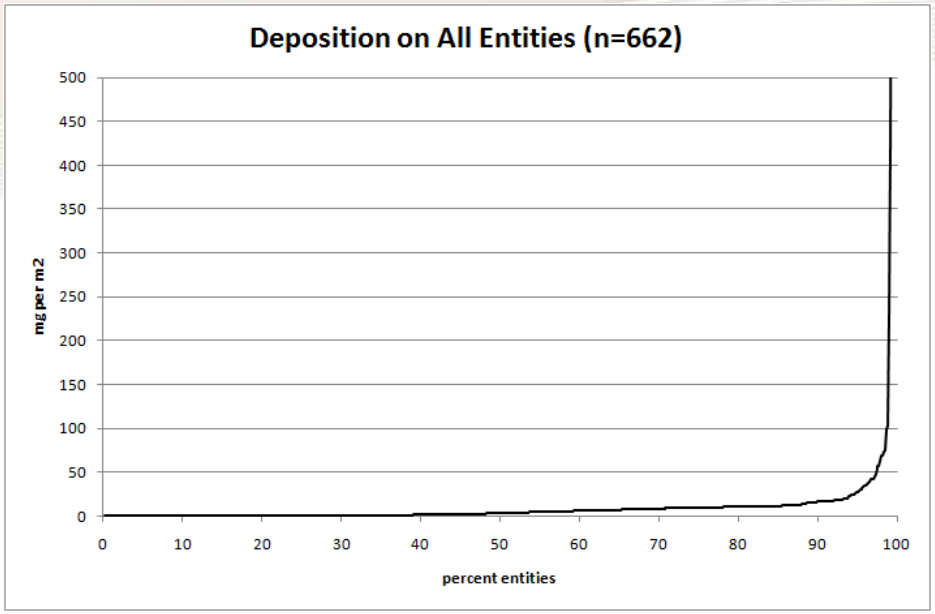
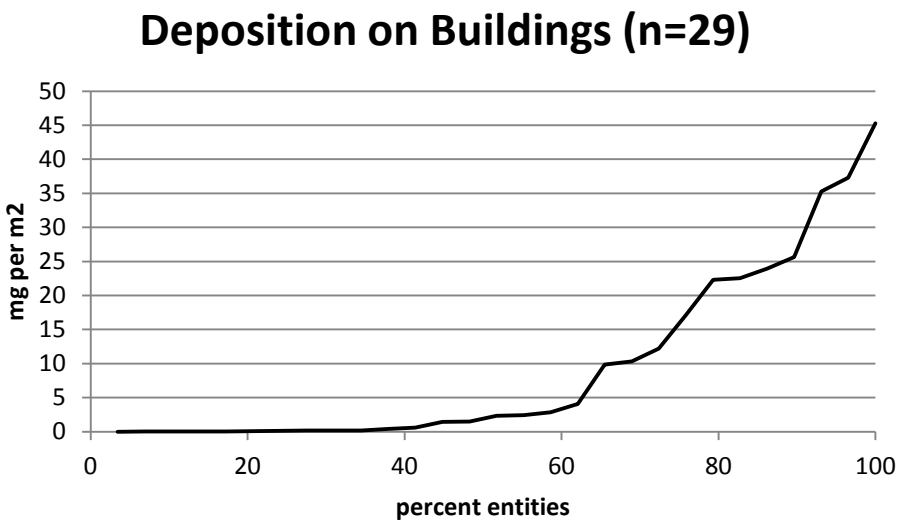
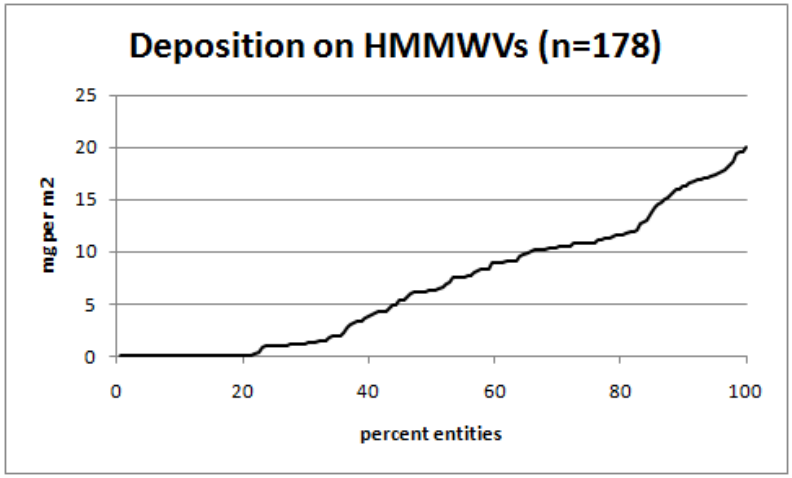
APOD Entities





Deposition Due to a Particular Chemical TBM Attack





IDA | Status

- Challenge Study has been published in Domestic and Exportable form (for use by ITF-46), is FOUO or FOUO//REL, along with a source term database (SECRET//NOFORN)
- Operational Challenge Study has been published, is classified SECRET//NOFORN
- NTA Challenge Study has been published, classified SECRET//NOFORN, but we consider some inputs now outdated (quick limited update done for JSTO)
- Defense Planning Scenarios study still in progress

IDA | Some Observations

- Old values (such as 10 g/m^2) may not have been transparent, but they are not necessarily wrong—they can be easily achieved locally under a number of conditions
- Considering casualties from fragmentation can change the challenge/risk trade-off by eliminating the highest challenge levels
- Entity analysis suggests that the distributions of challenge faced by widely dispersed entities (such as personnel) may be different from those that are collocated (such as aircraft)
- These approaches require metrics for operational risk (for example, what is the acceptability of a given level of contamination) as well as someone or body willing to set thresholds