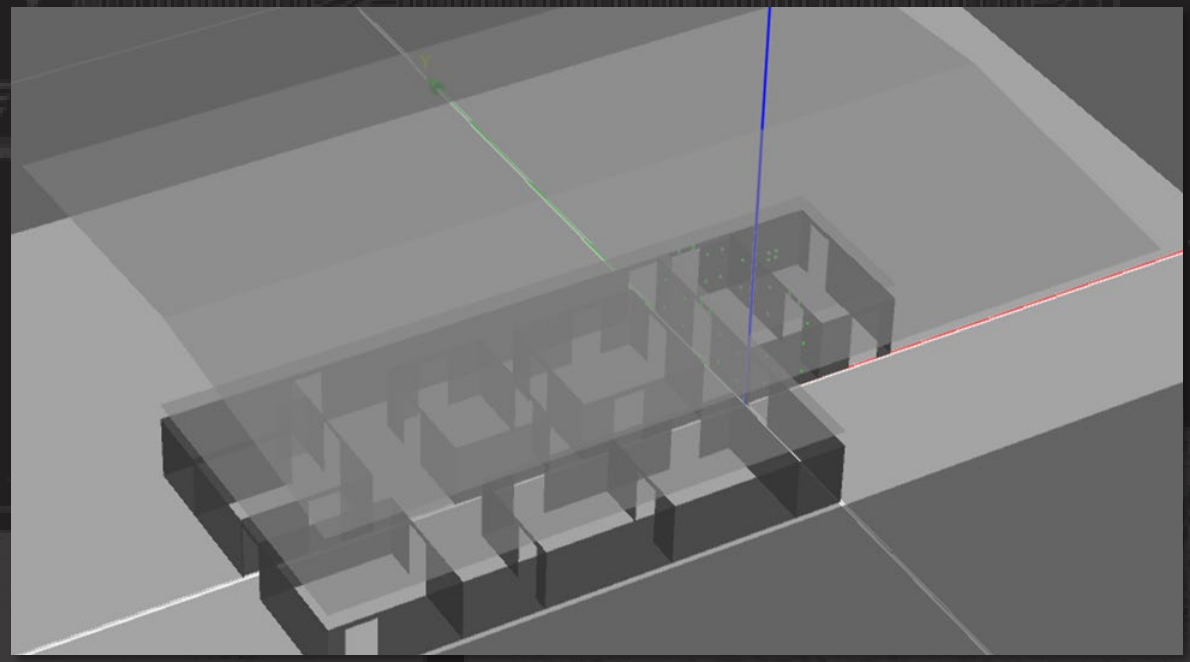
LOW LEVEL MILITARY OCCUPATIONAL BLAST (MOB) EXPOSURE AND MITIGATION

DDESB Summit

Prepared by Michael Pickett, PE
22 Jan 2026



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AGENDA

- Background & Overview
- Instructor Description of Effects
- Army BOP Working Group Overview
- Cognitive Baseline Testing
- FES MCX Role
- Preliminary Literature Review Findings
- BlastX Data
- Mitigation of BOP Through Material Modifications
- Decibel to Overpressure Correlation
- Facility Optimization for Exposure Reduction
- Conclusions
- Questions

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BACKGROUND

- In the last two decades an increase in understanding of repeated detonation effects on personnel has led to an increased focus on mitigation of risk to personnel.
- Two areas with an increased risk of TBI are artillery fire and breaching operations where training operations require personnel to be at a closer standoff to explosives.
- It has been found that in breaching operations instructors experience the most severe impacts due to the longer sustained exposure to operations than rotated students. Also, the instructor is often directly behind or next to the breaching student in the ‘stack’.

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BACKGROUND

"Blast injury studies are largely misunderstood. There are varying factors in determining how much overpressure a Breacher is exposed to based on his/her position in the assault stack. Add in the increased overpressure, of which varies with significant degree, when working inside structures and interior breaches. While safety precautions are adhered to, **it is evident that the effects of these detonations have an accumulative effect on the human brain.** As an instructor with the [DELETED], we conduct at least approximately 100 explosive breaches within a 2-week course. Times that by 8 courses a year and one can get a small glimpse at what instructors are exposed to yearly and how that can have a profound effect on day-to-day activity. From experience I can honestly say that after the conclusion of a 2-week course I feel exhausted. Headaches become more frequent, sleep cycles are disturbed, etc. **There should be annual or semi-annual medical checklists for personnel involved in dynamic entry and explosive operations on a regular basis.** I am in the process of having my experiences in [DELETED] documented in my medical record. Since there is no "MTBI" clinic to record and test individuals the whole process has been intermittent, to say the least. I have answered questions in front of health professionals and recently completed a brain MRI; both of which are important processes, yet **I am skeptical that those appointed as reading the MRI can assess the level of injury, if any, are present.**"

- Anonymous Breacher Instructor, Submitted in Health Screening Survey 2022

OVERVIEW

- This presentation notes ongoing developments in quantification of risk to personnel and means of mitigating exposures that are being actively worked or proposed by the various Army sub-working groups as well as ongoing efforts from the Special Operations Command (SOCOM).

INSTRUCTOR DESCRIPTION OF EFFECTS

- Personnel feel the worst during shotgun breaching, as opposed to explosives charge breaching.
- Shotgun breaching feels like a wave hitting at head and/or chest level at times.
- Worst feeling for explosives breaching is when personnel are at a standoff location that is more confined vs. a larger room.
- Feels worse inside of structure vs. exterior and on first floor vs. second, due to second floor having no ceiling.
- Can feel and hear the structure vibrating during breaching operations and it is adding to the adverse effects.
- Instructors feel the worst at the end of the six-week course.
- Feels worse if you lean against a wall in the stack.

ARMY BOP WORKING GROUP OVERVIEW

- **Army Blast OverPressure (BOP) Working Group**

  - The Army BOP Working Group was formed to bring the agencies involved in medical, operational, and engineering related functions together to form and execute a plan to quantify blast exposure on personnel from various operations, determine risk at various blast exposure levels, and develop and implement engineering solutions for reducing risk.

  - Sub-working groups were later formed for medical and engineering solutions.

ARMY BOP WORKING GROUP OVERVIEW

- **Medical Sub-Working Group**

  - The Medical Sub-Working Group is focused on determination of appropriate testing methods for mTBI, appropriate data collection means, and establishing exposure thresholds for points of risk of mTBI occurring. (dose-response)

  - This group found that the lack of rigorously methodical data from adequately detailed studies makes risk determination for BOP dose-response challenging.

  - Released interim guidance reiterating the 4-psi threshold for overpressure generating potential brain health risk and added an interim 31-psi*ms threshold as well. They are still investigating if cumulative exposure can reduce these thresholds.

  - Over ¾ of high-risk military personnel have been tested for cognitive baselining in the last year. Once this testing is complete, the risk of the Army will be tested, and the high-risk personnel will be re-evaluated directly following their respective exercises to measure changes in their baseline evaluations.

ARMY BOP WORKING GROUP OVERVIEW

- **Engineering Solutions Sub-Working Group**

  - This sub-working group is focused on determination of available and new methods for reducing overpressure and impulse exposure to personnel.

  - In general, many of these solutions involve potential modifications to weapon systems due to limited standoff from the source of overpressure to personnel in artillery and other training operations.

  - Proven 80% solutions were used as a starting point for initial proposals, with 50% solutions following behind.

COGNITIVE BASELINE TESTING

- **Cognitive Baseline Testing of High-Risk Personnel**

  - Following a policy directive from the Department of War (DOW) in August 2024, the U.S. Army initiated a cognitive baseline testing program for high-risk personnel.

  - The testing is used to establish a service member's baseline cognitive function, which can be referenced later in their career to more easily diagnose subtle neurological changes

  - Initial testing focuses on personnel during initial entry training and those in high-risk, active-duty roles, with a long-term goal of testing all service members.

  - This baseline cognitive testing sets a path forward for substantially improving DoD understanding of which explosives and live-fire operations present hazardous exposures for personnel. This information will then be used to inform working groups on prioritization of research and development as well as confirm or counter current understanding of pressure and impulse levels that correlate to heightened risk of mTBI.

FES MCX ROLE

- **Facilities Explosives Safety (FES) Mandatory Center of Expertise (MCX) Role**

  - The FEX MCX supports projects involving the design, construction, or modification of facilities that manufacture, store, handle, maintain, develop, demilitarize, test, or dispose of ammunition or explosives.

  - The FES MCX has worked on various efforts to improve DoW understanding of the impact of modifications to structural systems on blast overpressure and impulse exposure to personnel. Several of these items and efforts are outlined in the following sections.

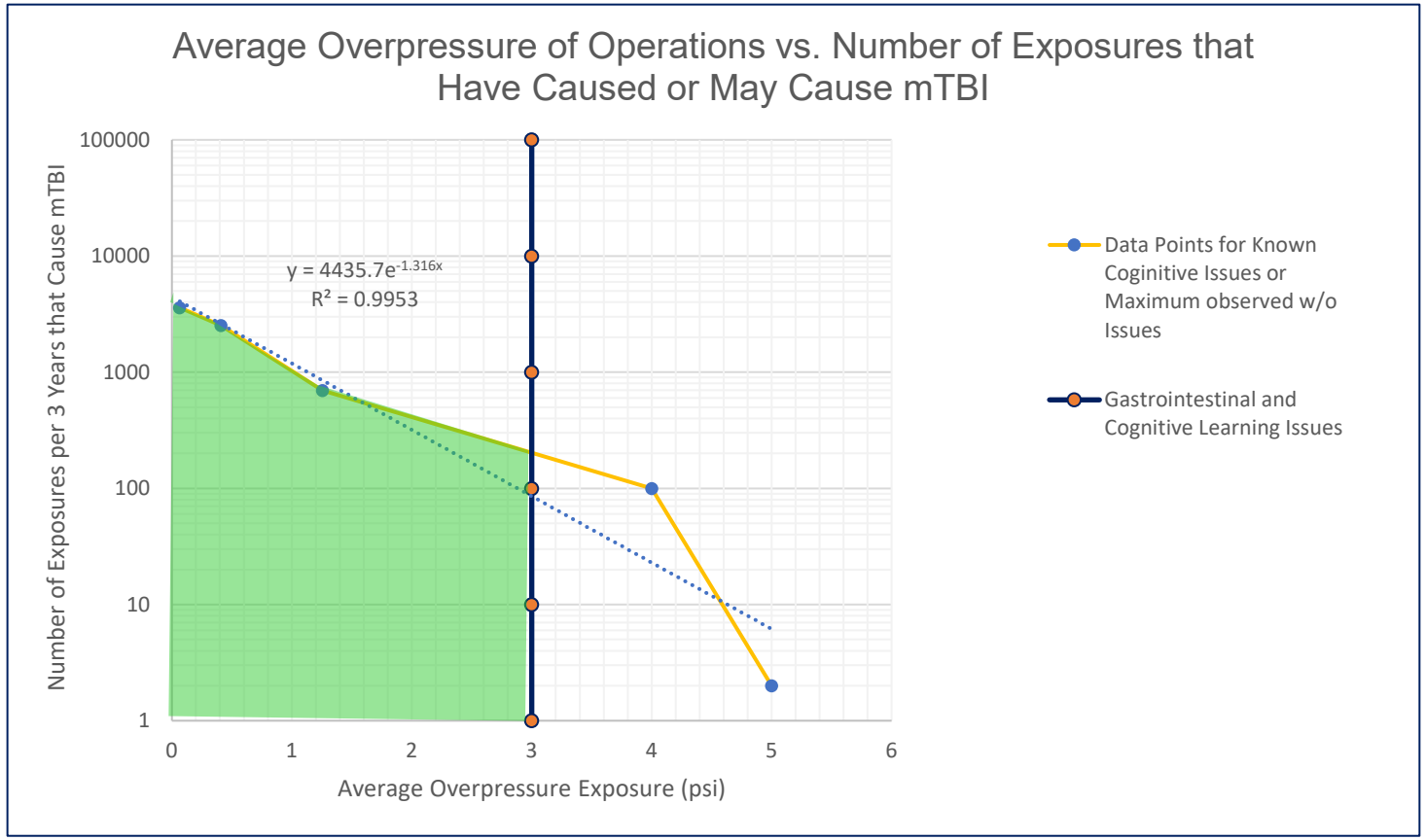
LITERATURE REVIEW

- Current DoW explosives safety criteria were examined for any exposure thresholds that may be useful in understanding some of the adverse symptoms occasionally experienced in live-fire training.

Codified Pressure Based Thresholds for Personnel Protection			
DoD Source	**Limit (psi)**	**Desc.**	**Threshold**
DESR 6055.09	0.065	K328	Intentional Detonation Siting for Repeated Detonations (IDS) for Non-essential Personnel
DESR 6055.09	0.9 or 1.2	K40 or K50	Inhabited Building Distance (IBD) Protection for Unrelated Personnel from Accidental Detonations
DESR 6055.09	2.3	K24	Remote Operator Protection for Accidental Detonation and IDS Essential Personnel
DESR 6055.09	3.5	K18	Essential Personnel Limit for Related Personnel to Adjacent Explosives Operations of Successive Steps (Intraline Distance, ILD)
DoD Field Activity Memo	3.5	K18	Standard Breaching Minimum Safe Distance (MSD)
DoD Memorandum	4	-	Interim guidance on live-fire training exposure threshold for mTBI risk
DESR 6055.09	12	K9	Barricaded Intraline Distance (ILD). Only Used if Barricade is Included Between Buildings and Allowable Buildings for Siting Type
UFC 3-340-02	5	-	Threshold for Eardrum Rupture
UFC 3-340-02	30	-	Threshold for Lung Damage
UFC 3-340-02	120	-	Lethality
UFC 3-340-02	Varies	-	Temporary Hearing Threshold Shift

LITERATURE REVIEW

- After examining existing DoW criteria and available data, a literature review was performed regarding overpressure and impulse exposures that led to adverse cognitive and/or gastrointestinal effects.
  - Data was targeted that contained enough information for cumulative exposure determination.



Literature Review Data Points for Cumulative Overpressure Effects on Personnel			
Reference	**Peak Pressure (psi)**	**No. of Exposures per Three Years**	**Effect**
25	5	2	mTBI
5	4	100*	mTBI
24	3	3	Gastrointestinal Issues
24	3 to 10	Various	Reductions in Cognitive Learning Ability
32	1.256	696	mTBI
26	0.35	3600	mTBI

BLASTX PREDICTED OVERPRESSURE V. FIELD DATA

- **Interior and Exterior Charges:**

Table 1: Explosives Charge Types

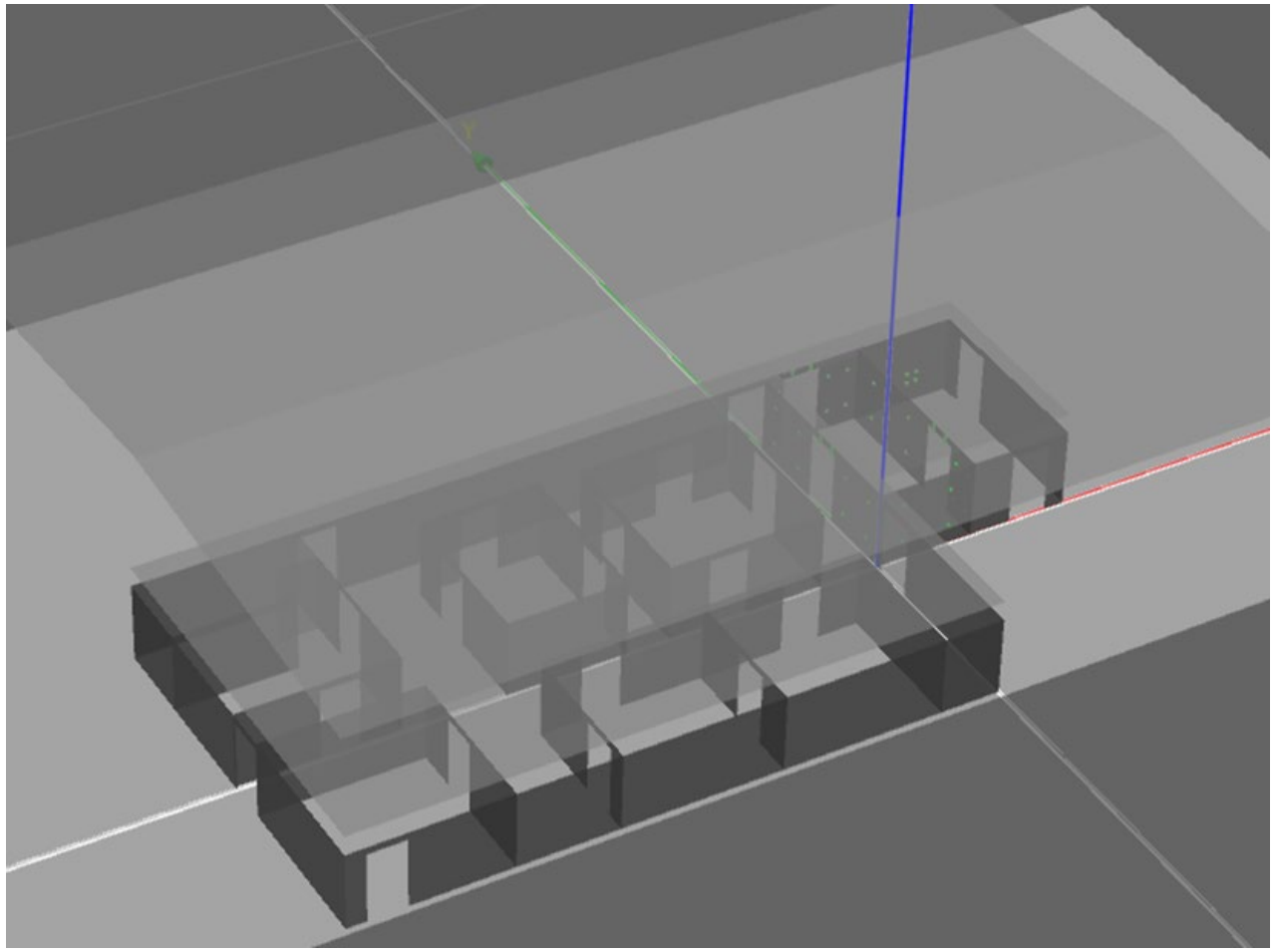
Explosives Charge Type	NEW (lbs.)	Codified MSD K18 (ft)	Interior MSD (ft)	Exterior MSD (ft)
Slap Charge E.C.T. 300	0.1	8.33	30	15
Nunchuk Charge E.C.T. 300	0.221	10.96	Not Used Inside	15

Table 2: Incident Pressure at Assumed Safe Distances

Explosives Charge Type	NEW (lbs.)	MSD (ft)	Scaled Standoff (ft/lbs.^(1/3))	Incident Pressure (psi)
Slap Charge E.C.T. 300	0.1	8.33	17.95	3.51
Slap Charge E.C.T. 300	0.1	30	64.63	0.64
Slap Charge E.C.T. 300	0.1	15	32.32	1.54
Nunchuk Charge E.C.T. 300	0.221	10.96	18.13	3.46
Nunchuk Charge E.C.T. 300	0.221	15	24.81	2.20

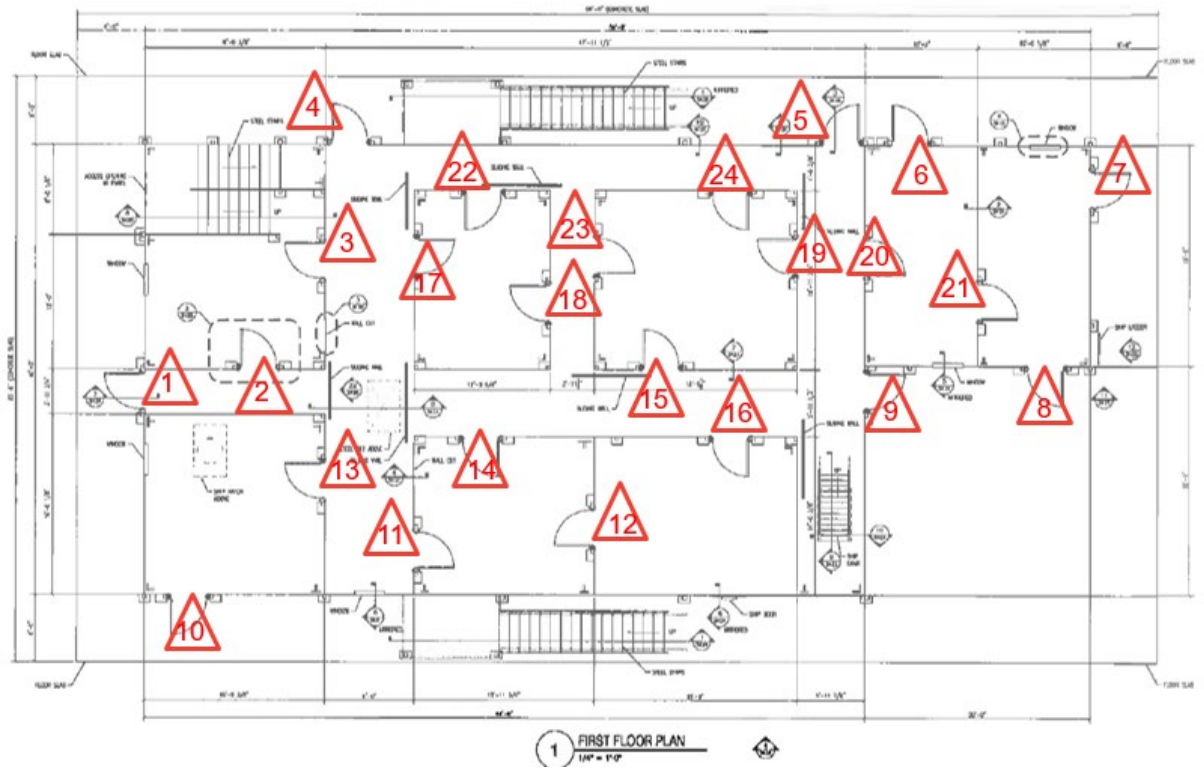
BLASTX PREDICTED OVERPRESSURE V. FIELD DATA

- **BlastX Model for Breacher Facility:**



BLASTX PREDICTED OVERPRESSURE V. FIELD DATA

- **Interior and Exterior Charges Gauge Data:**



BlastX Recorded Pressures		
Overpressure Range	**Quantity**	**Percentage**
0 to 1	38	33.9%
1 to 2	72	64.3%
2 to 3	1	0.9%
3 to 4	1	0.9%
Total	112	

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BLASTX PREDICTED OVERPRESSURE V. FIELD DATA

- **Interior and Exterior Charges Gauge Data:**

Charge Locations	Peak Overpressure (psi) at 30 ft. Standoff			
	Plan North	Plan South	Plan East	Plan West
1 (EXT)	1.644	1.805	NA	NA
1 (INT)	1.422	1.232	NA	NA
2 (TOP)	1.256	NA	1.333	NA
2 (BOTT)	NA	1.185	0.875	1.203
3 (LEFT)	NA	1.178	NA	1.297
3 (RIGHT)	1.236	0.931	1.004	NA
4 (EXT)	NA	NA	1.613	1.824
4 (INT)	NA	1.064	1.049	NA
5 (EXT)	NA	NA	1.428	1.573
5 (INT)	NA	1.101	1.205	1.126
6 (EXT)	NA	NA	1.779	1.471
6 (INT)	NA	1.065	1.411	1.438
7 (EXT)	NA	1.864	NA	1.618
7 (INT)	NA	1.096	NA	1.438
8 (EXT)	1.670	1.349	NA	1.364
8 (INT)	1.064	NA	NA	1.488
9 (EXT)	NA	1.723	1.654	NA
9 (INT)	1.260	NA	NA	0.905
10 (EXT)	1.483	NA	1.325	NA
10 (INT)	1.021	NA	1.418	NA
11 (LEFT)	0.912	NA	NA	1.245
11 (RIGHT)	0.969	NA	0.9604	NA
12 (LEFT)	1.268	NA	NA	1.028
12 (RIGHT)	1.114	NA	1.100	NA
13 (LEFT)	NA	0.984	NA	0.883
13 (RIGHT)	0.882	NA	0.976	NA
14 (TOP)	1.007	NA	0.907	0.969
14 (BOTT)	NA	NA	1.367	0.946
15 (TOP)	1.252	NA	0.837	1.167
15 (BOTT)	NA	1.341	0.932	0.874
16 (TOP)	0.836	NA	0.905	0.904
16 (BOTT)	0.900	NA	NA	0.944
17 (LEFT)	1.195	0.906	NA	1.216
17 (RIGHT)	NA	2.607	0.975	NA
18 (LEFT)	0.948	NA	NA	1.224
18 (RIGHT)	0.772	1.109	NA	0.916
19 (LEFT)	1.123	1.487	0.894	NA
19 (RIGHT)	0.908	0.900	NA	0.972
20 (LEFT)	0.909	0.909	NA	1.122
20 (RIGHT)	0.904	1.028	0.841	NA
21 (LEFT)	1.026	3.009	NA	1.140
21 (RIGHT)	1.139	1.062	0.878	NA
22 (TOP)	0.841	0.903	NA	1.087
22 (BOTT)	NA	0.968	1.229	0.892
23 (LEFT)	NA	1.060	NA	0.934
23 (RIGHT)	0.838	NA	1.147	NA
24 (TOP)	1.015	NA	0.856	0.903
24 (BOTT)	NA	0.917	0.934	0.984

*ALL PRESSURES BELOW (K18 Equivalent) 3.5 PSI

BLASTX PREDICTED OVERPRESSURE V. FIELD DATA

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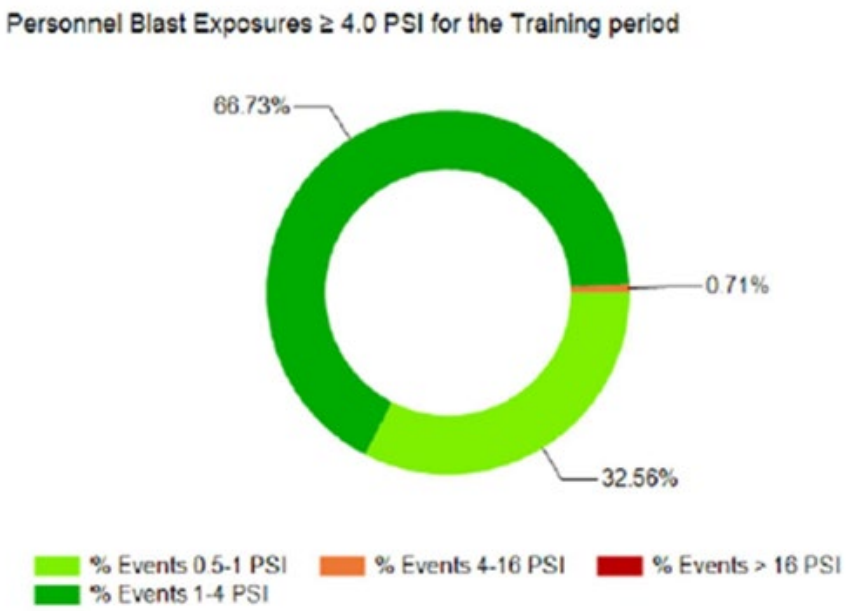

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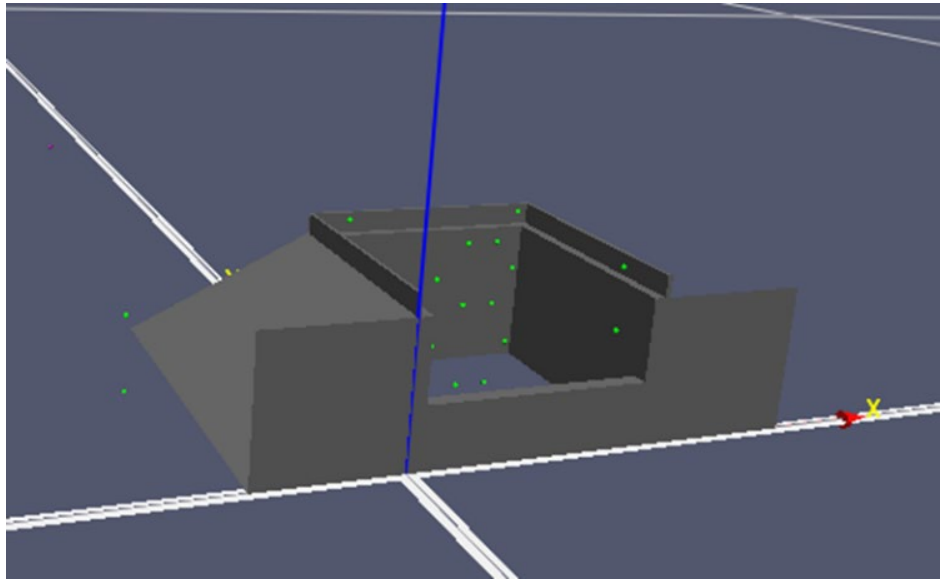
BLASTX PREDICTED OVERPRESSURE V. FIELD DATA

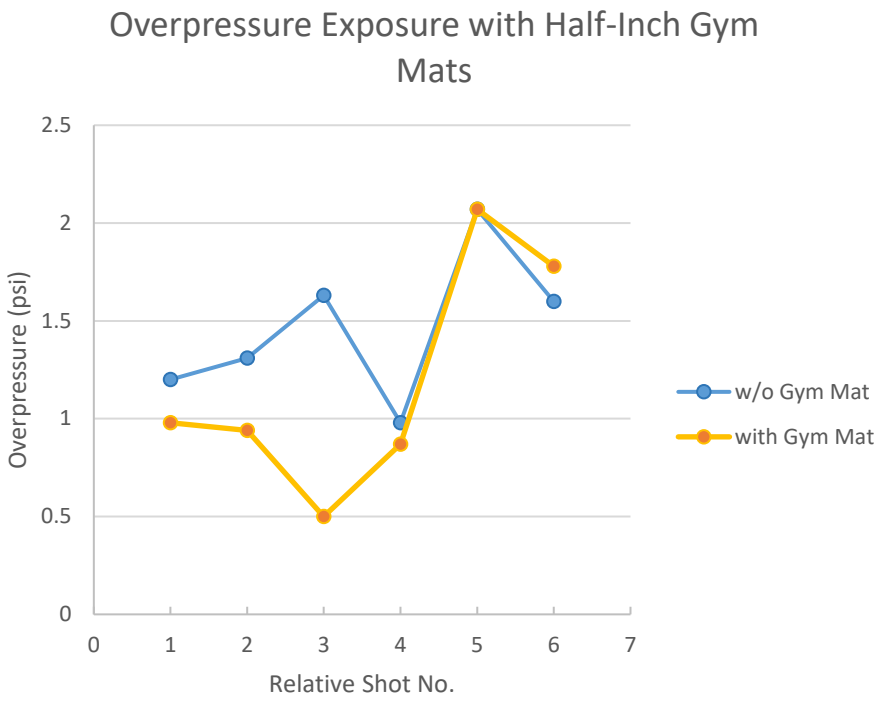
- **Grenade Training Pit:**



Wearable Gage Average peak pressure – 1.4 psi
UFC 3-340-02 – 1.2 psi (10m) (17% error)
BlastX – 1.27 psi (10m) (10% error)

MITIGATION OF BOP THROUGH MATERIAL MODIFICATIONS

- **Shotgun Breaching Data:**



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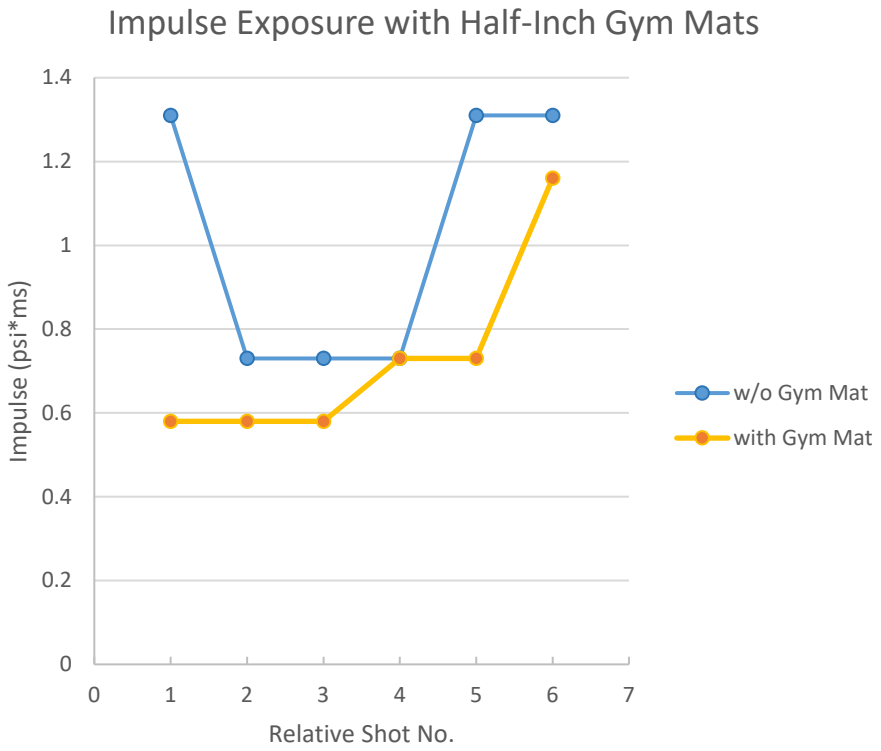
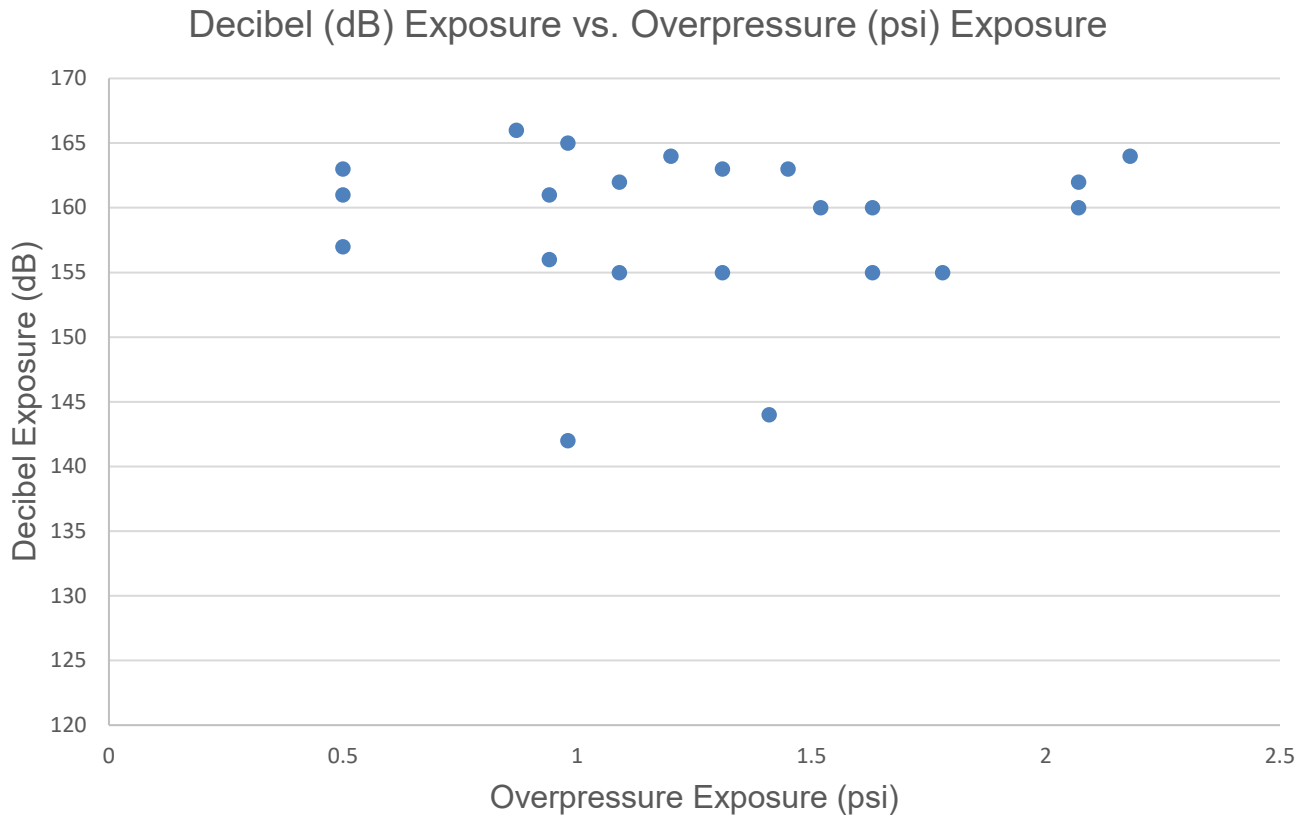


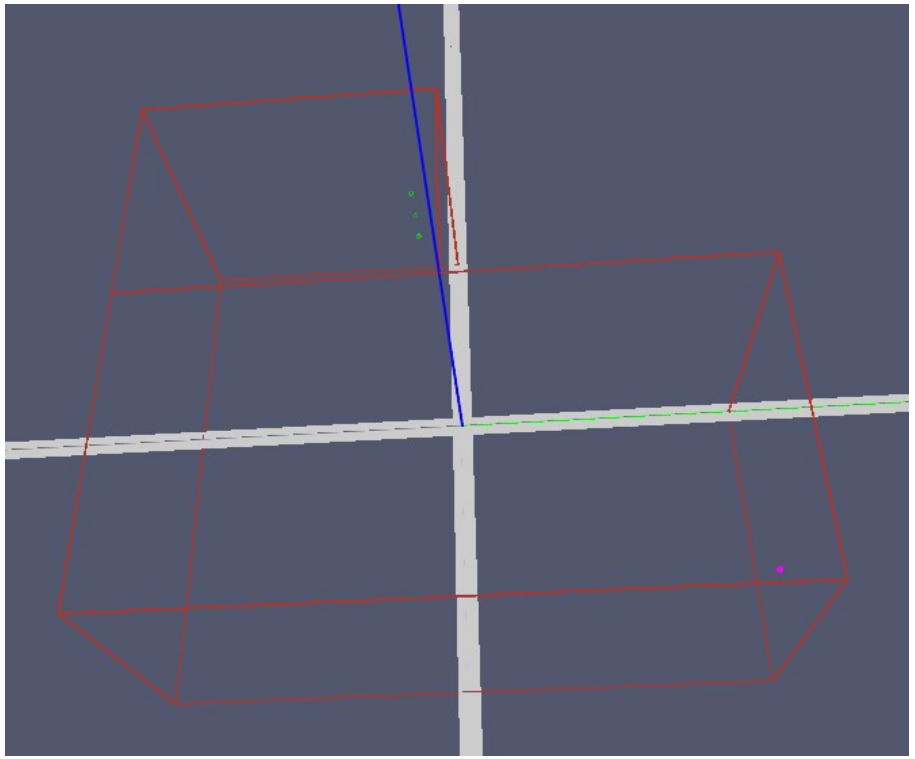
DECIBEL TO OVERPRESSURE CORRELATION

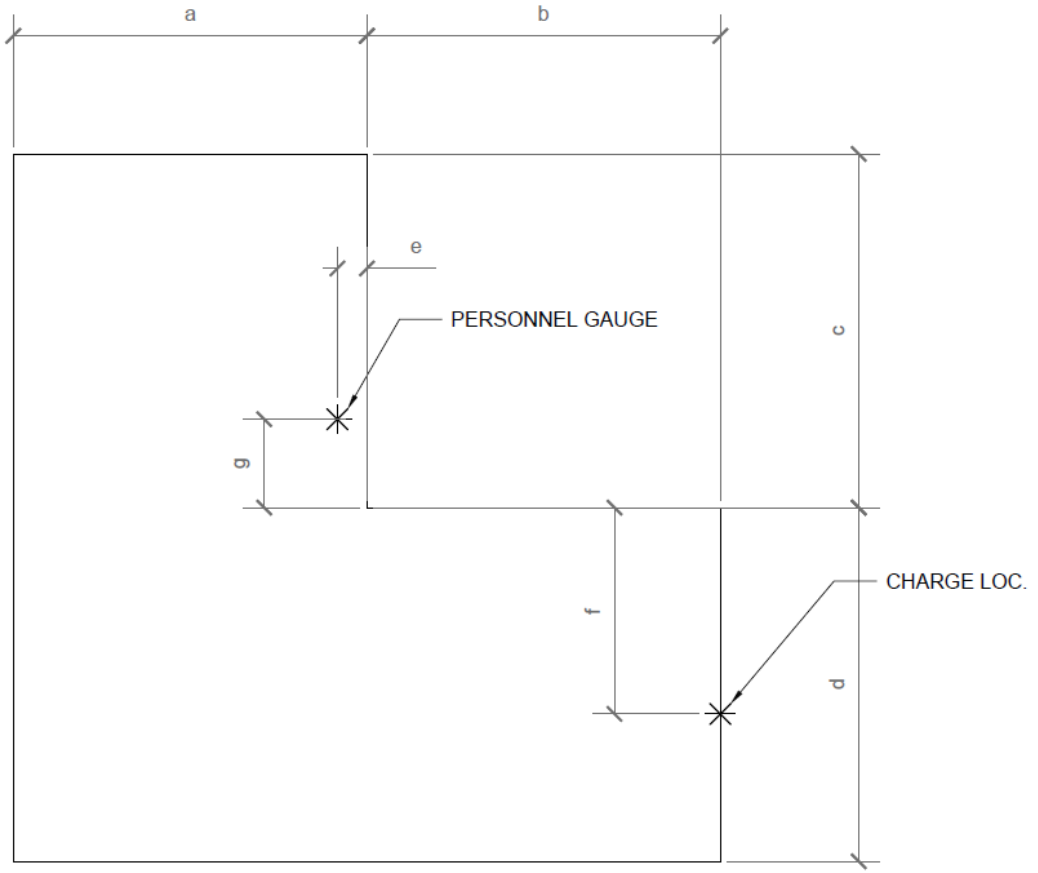
- **Overpressure (psi) v. Decibel (dB):**



FACILITY OPTIMIZATION FOR OVERPRESSURE REDUCTION

- **BlastX example using L-Shaped Room**





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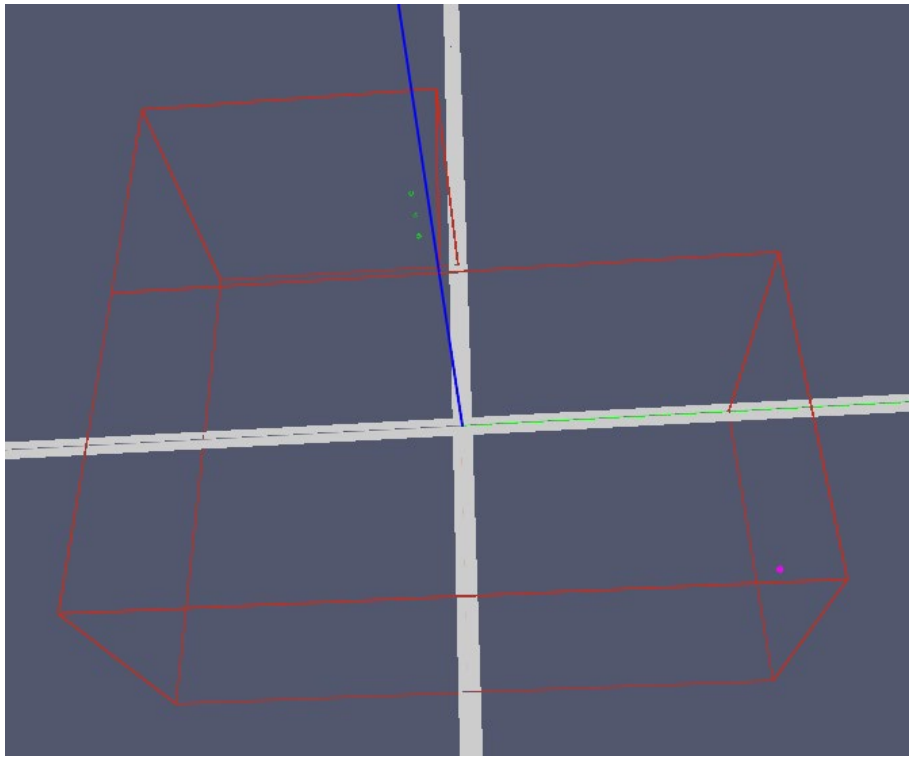

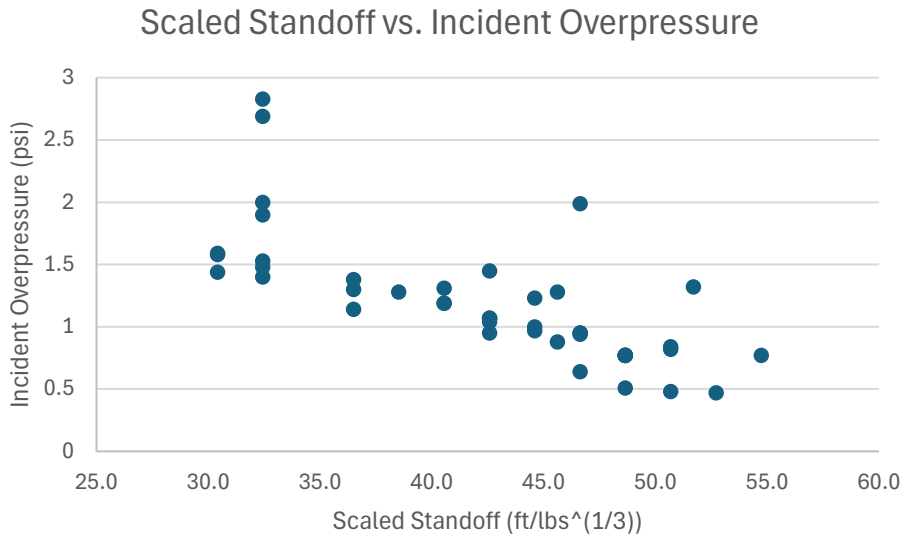

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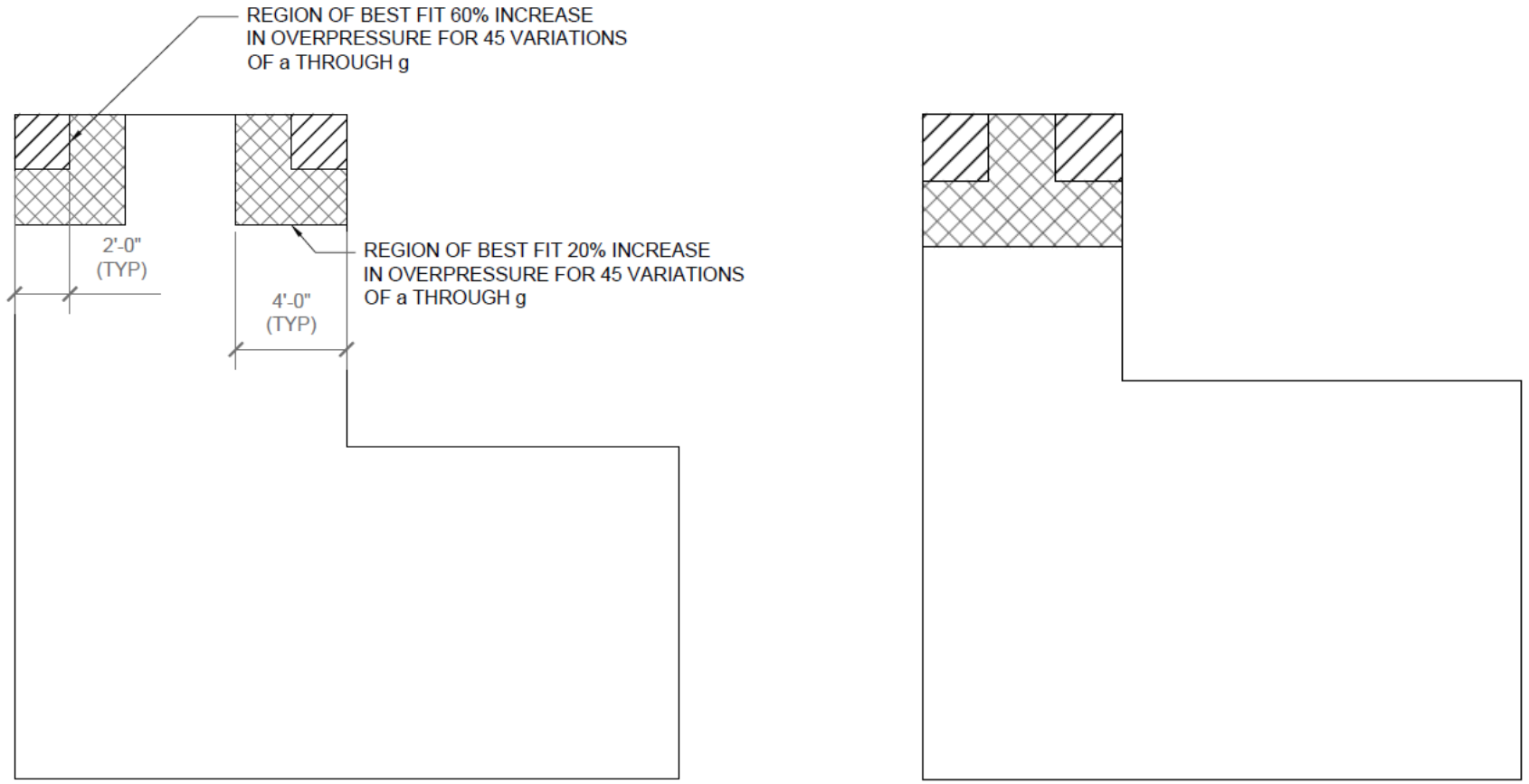

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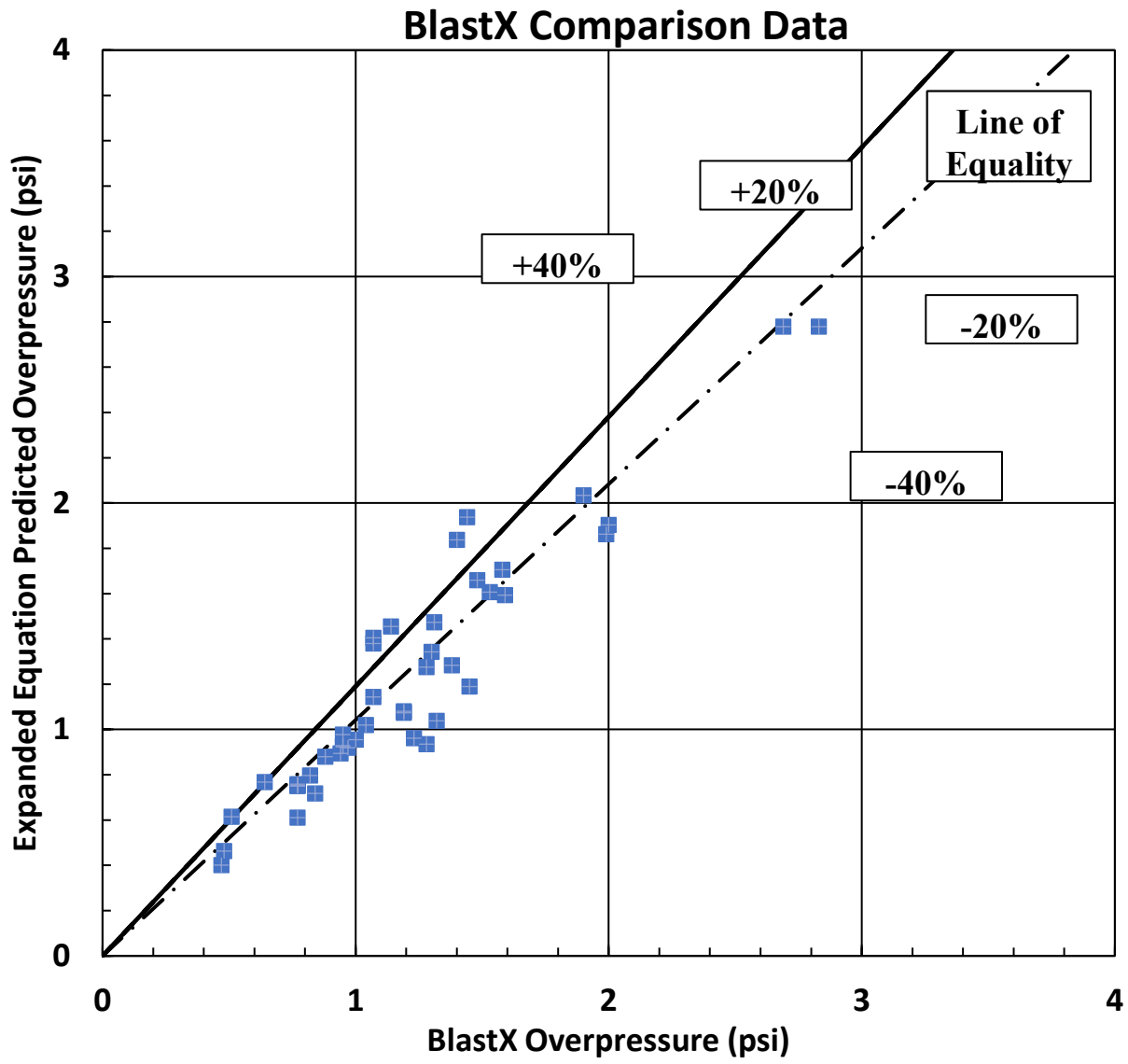

CONCLUSIONS

- Conclusions:
- There are many ongoing efforts in the area of blast overpressure reduction and mTBI risk from live-fire training.
- The ongoing cognitive baseline testing on personnel is likely to be the most beneficial in the short term due to being the next step in quantifying the numbers and groups of personnel with the highest risk of mTBI and having data to compare against expected exposure levels of risk
- This data will then feed the engineering solutions development and medical working group research.
- It is recommended that the Explosives Safety community does not attempt any criteria modifications based on BOP findings until collected data is more complete. At this point the 4-psi threshold would not impact DESR 6055.09 criteria.

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QUESTIONS?