DoD Non-Lethal Weapons Program

Human Effects Center Of Excellence

Non-Lethal Weapons Human Effects

14 May 2014

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NLW Human Effects Core Functions

DoD Non-Lethal Weapons Human Effects			
S&T, R&D, and Transition & Integration Support	**Modeling and Simulation**	**Combat and Material Development Support**	**Education, Communication, Subject Matter Expertise**
• Planning Support • HE Project Mgmt • Support Demos	• Develop HE Models • Run Simulations • HE Model V&V	• SME/Documentation KSA, KPP Development • Target HE Eval Planning • AoA's	• Legal, Treaty, Policy Support • Maintain HE Database

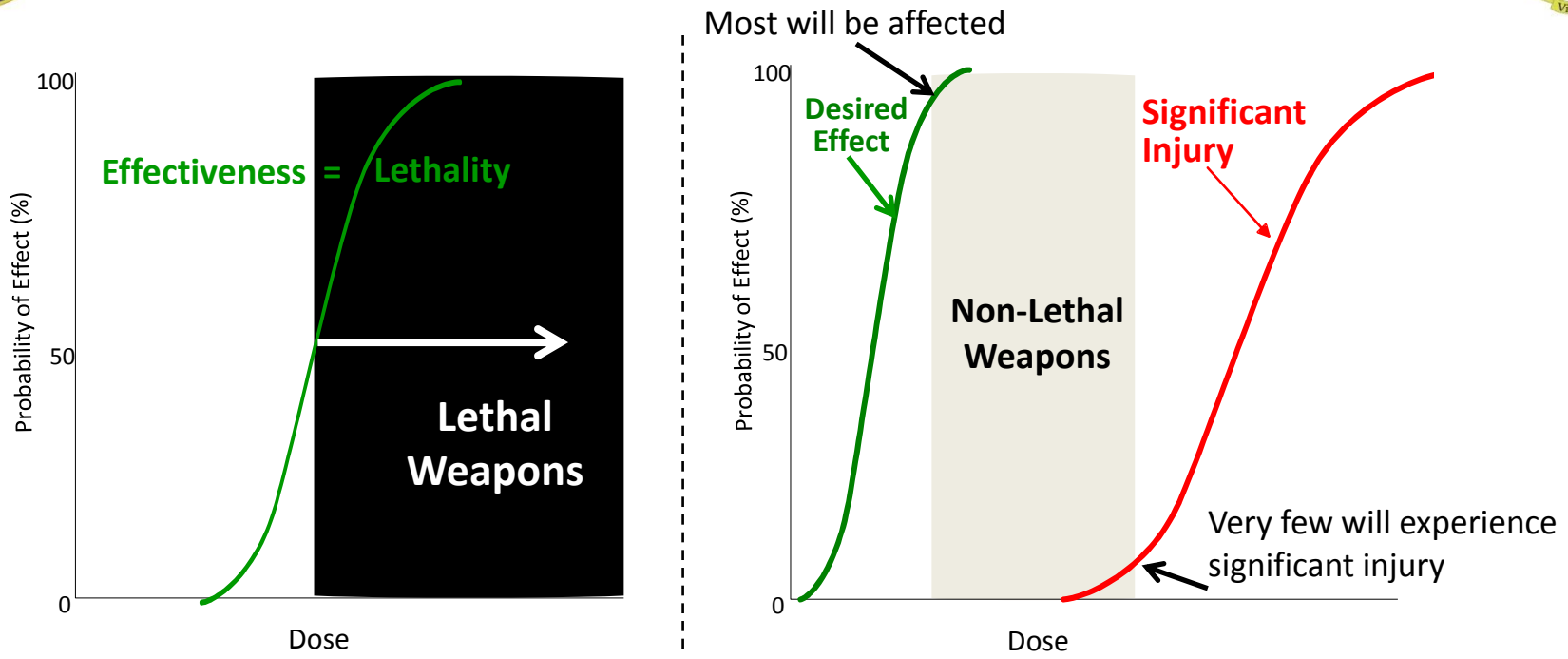
DoD NLW HE Team:

Joint Non-Lethal Weapon Directorate (JNLWD) Human Effects Office

Human Effect Center of Excellence (HECOE)

BLUF: Ensure warfighters have the confidence to employ NLW

NLW Human Effects Characterization



- Generally, the goal of lethal weapons has been to maximize a single effect (lethality) while meeting the constraints of the Law of Armed Conflict (LOAC), logistics, cost, etc.
- For NLW, two competing objectives exist: cause a desired effect on the target, while minimizing permanent injuries or fatalities and maintaining low collateral damage.
- Understanding human effects is critical for legal/treaty reviews, policy acceptability, and operator awareness.

DoD Instruction 3200.19

• Describes DoD policy, responsibilities and procedures for human effects characterization of NLW technologies and systems

• Establishes Risk of Significant Injury (RSI) as the metric for reversibility and the health care capability (HCC) indices as a basis for making RSI calculations

• “The RSI for any given weapon shall be identified by the combat developer to assist in materiel development and enable force commanders to understand the potential risks associated with the use of specific NLW.”

• “Combat developers, working with warfighter input, shall determine the human effects-related performance attributes of NLW, to include acceptable RSI. … RSI shall be addresses as a KSA or KPP.”

What is Risk of Significant Injury (RSI)?

- RSI is the probability that a NLW system will cause a significant injury when used as intended

- IAW DODI 3200.19, “Significant” injuries include:
  a) any injury requiring Health Care Capability indices 1 or 2
  b) permanent injuries
  c) death

- RSI values are presented as the probability of an injury (or injuries) occurring to an individual being “significant” given the system’s intended use

Health Care Capability Indices

	HCC 0	Limited First Responder Capability: Self-aid, Buddy Aid, and Combat Lifesaver Skills
Significant Injuries	HCC 1	First Responder Capability: Requiring Stabilization and Emergency Care
	HCC2	Forward Resuscitation and Theater Hospitalization Capabilities: Advanced Emergency, Surgical, and Ancillary Services

*** Derived from Joint Publication 04-02, Health Services Support, 31 Oct 2006**

General RSI Equation

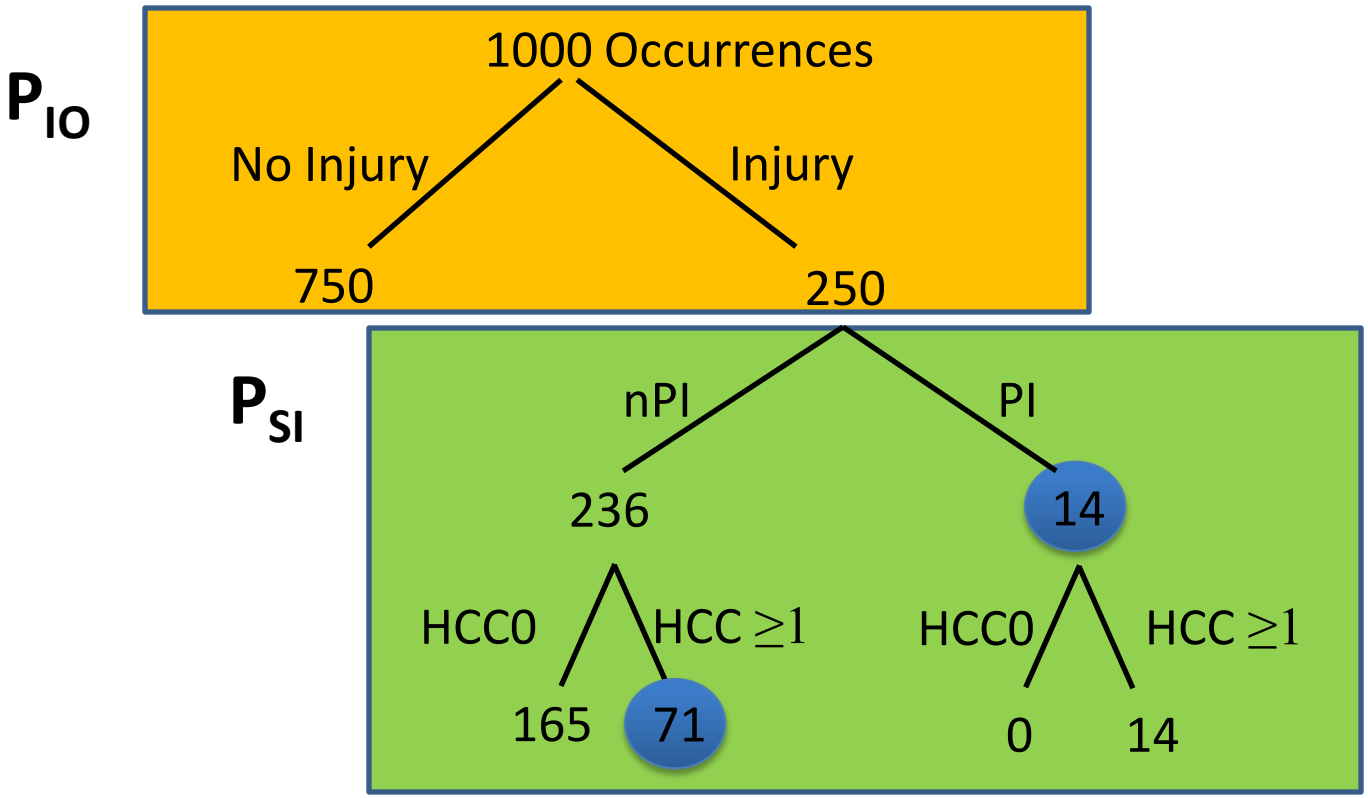
$$P_{RSI,\,Injury} = P_{IO} * P_{SI}$$

P_{IO} is probability that injury will occur given the nature, location, and intensity of the insult

P_{SI} is probability that injury will be significant (HCC1+ or permanent) given that type and severity of injury occurs

RSI Diagram – Single Injury Modality

RSI essentially sorts injuries into significant injury "bins": is the injury permanent OR require HCC≥1?

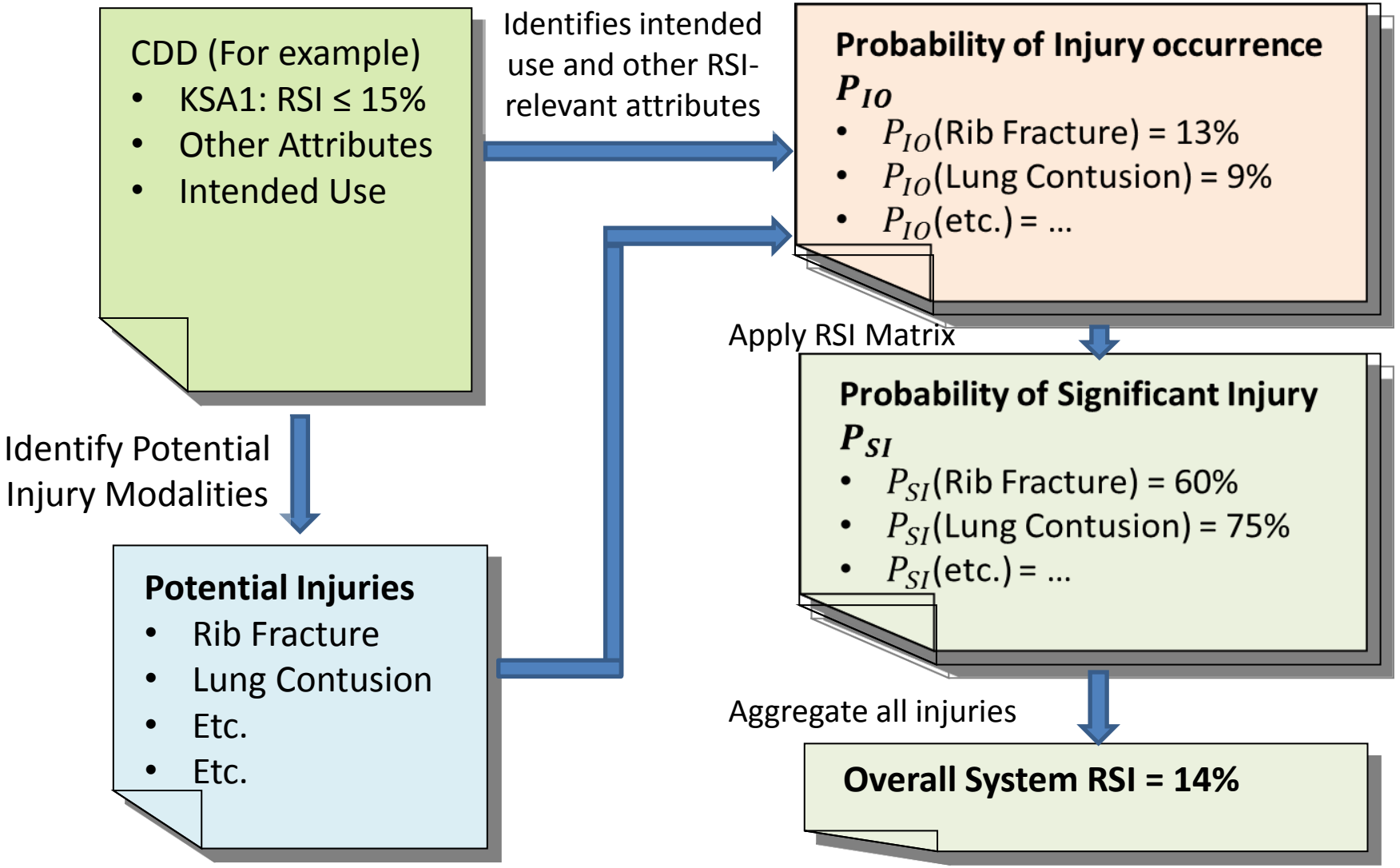


RSI = (250/1000)*(71+14)/250 = .085 or 8.5%

Estimating P_{SI} Medical Expert Survey

Injury	P_{PI} Mean	P_{PI} SD	P_{HCC0} Mean	P_{HCC0} SD	P_{HCC1} Mean	P_{HCC1} SD
Skull Fracture - Hairline	1.92%	3.15%	96.6%	6.30%	3.45%	6.30%
Skull Fracture - Linear	4.75%	5.63%	90.8%	14.7%	9.25%	14.7%
Skull Fracture - Depressed	44.3%	35.7%	25.9%	27.5%	74.1%	27.5%
Cerebral Concussion - Mild	7.50%	5.32%	92.9%	6.32%	7.08%	6.32%
Cerebral Concussion - Severe	46.9%	31.3%	41.2%	34.5%	58.9%	34.5%
Diffuse Axonal Injury	74.5%	28.8%	0.20%	0.42%	99.4%	1.50%
Mandible Fracture	29.4%	36.4%	22.0%	28.9%	84.1%	19.7%
Globe Rupture	92.5%	9.17%	0.17%	0.39%	99.8%	0.39
Corneal Abrasion	2.17%	2.92%	89.3%	10.4%	10.7%	10.4%
Hyphema	23.3%	24.7%	41.2%	34.5%	58.9%	34.4%
Lens Dislocation	55.4%	39.2%	2.58%	6.19%	97.4%	6.19%
Retinal Damage	64.5%	27.5%	36.9%	43.5%	63.2%	43.5%
Mild Lung Contusion	9.64%	10.5%	79.4%	8.44%	20.6%	8.44%
Moderate Lung Contusion	34.4%	29.3%	11.7%	10.3%	86.2%	12.4%

Flow of System RSI Assessment



Sample Aggregate Calculation
Flash Bang @ single target location

Injury Modality	P_{IO}	HCC 0	HCC 1/P_{PI}
Multiple Rib Fracture	20%	40%	60%
Lung Contusion (mild)	15%	79%	21%
Liver Laceration (mild)	10%	80%	20%
1st Degree Burn	80%	100%	0%
2nd Degree Burn	15%	57%	43%
Retinal Lesion	5%	37%	63%
PTS	6%	0%	100%

Rib Fracture P_{RSI} = .2.6= .12*

Lung Contusion P_{RSI} =.15.21=.031*

Liver Laceration P_{RSI} = .1.2= .02*

*1st Degree Burn P_{RSI} = .8*0= 0%*

2nd Degree Burn P_{RSI} =.15.43 = .064*

Retinal Lesion P_{RSI} = .05.63 = .031*

*PTS P_{RSI} =.06*1 = .06*

Aggregate P_{RSI} = 1-[(1-.12)(1-.031)*(1-.02)*(1-0)*(1-.064)*(1-.031)*(1-.06)]*
= .28 or 28%

Human Effects Modeling Analysis Program Vision, Mission, & Scope

VISION:
NLW technology developers and the DoD T&E community are able to use human effects knowledge to improve technology design, establish trade spaces, and verify HE-related system attributes and mission effectiveness.

MISSION:
Utilize NL human effects research to develop a suite of human effects models that can be used to predict effects, effectiveness, and risk of significant injury.

SCOPE:
- Model development to include:
  - Empirical models (models of data)
  - Computational models
  - Instrumented test targets
  - Surrogates
- Model calibration
- Model V&V

OUT OF SCOPE:
- Model accreditation
- Conducting simulations
- Test target procurement

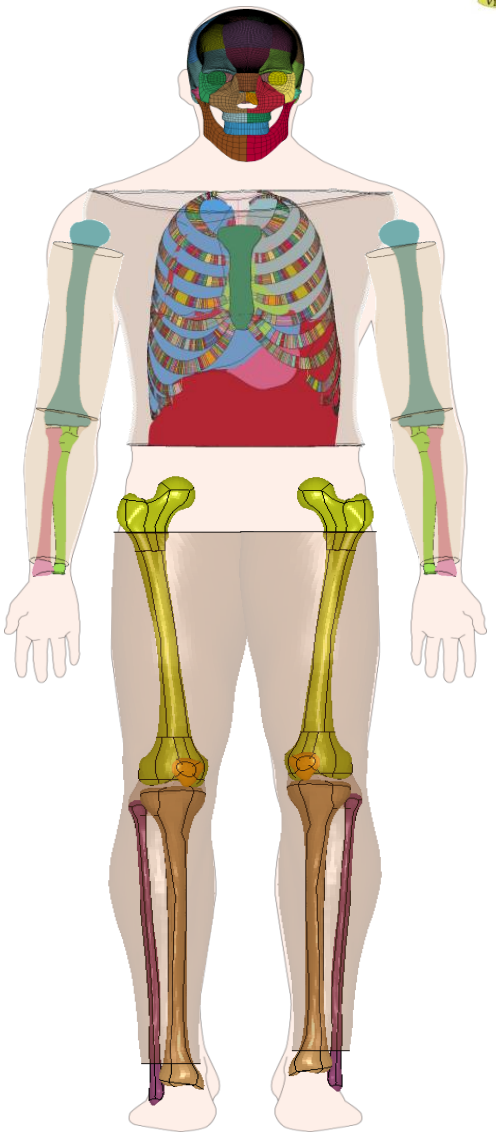
HEMAP Priorities

Develop human effects models and surrogates to support:

1. Service-led Systems Acquisition Programs
2. Technology development efforts
3. Prediction fidelity upgrades
4. HE applied research
5. Next generation effects
6. Improving visualization of HE results (improve understanding and communication)

Focus on predicting:

- Risk of Significant Injury
- Effects, Efficacy, and/or Effectiveness



HEMAP Customers and Stakeholders

Customers:

- Technology/Material Developers
  - Evaluate trade offs of RSI and effectiveness with other system specifications.)
  - Assess RSI and effectiveness of technology development and commercial products (can inform AoAs)
- Developmental Testers
  - Conduct developmental testing
    - "Did the technology do what it was designed to do?"
    - Acceptance lot testing
- Operational Testers
  - Conduct operational testing
    - "Did the material developer design the right thing?"

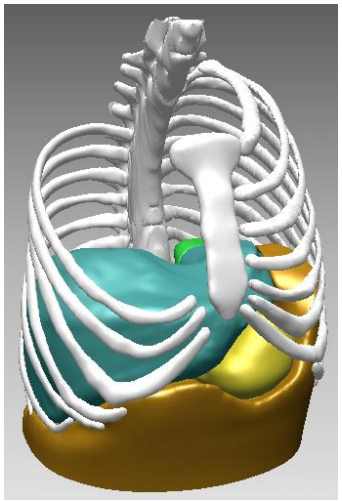
Stakeholders:

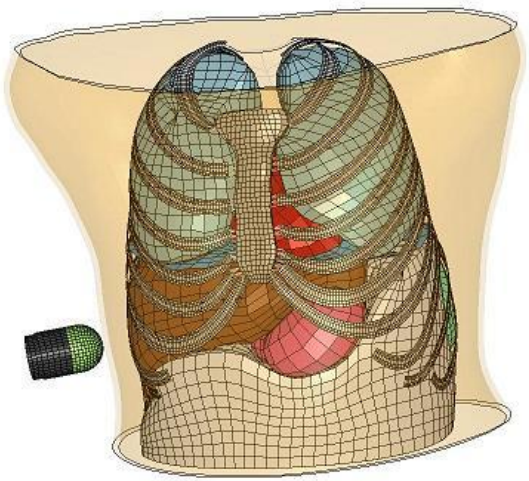
- Customers
- JNLWD
- HECOE

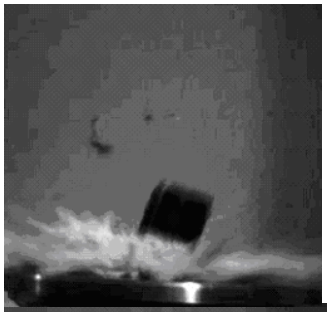
Different customers may have different requirements

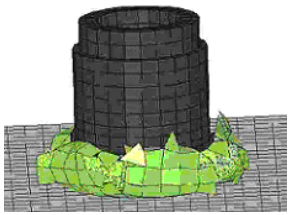
Advanced Total Body Model (ATBM)

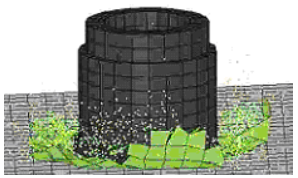
- ATBM is a JNLWP-sponsored Finite Element (FE) based blunt trauma injury prediction model
- Biomechanically based, applicable for NLW impacts, and validated against animal and cadaveric data
- Predicts a variety of injuries for the head, thorax, abdomen, skin, and extremities
- Includes design optimization and probability of hit modules
- Established projectile characterization process including static and dynamic loading to develop projectile FE model

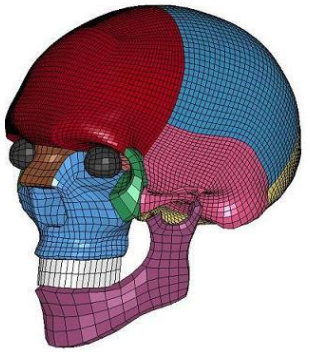




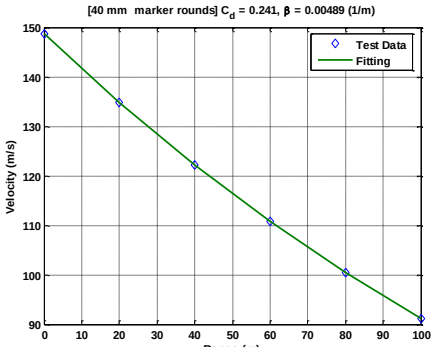


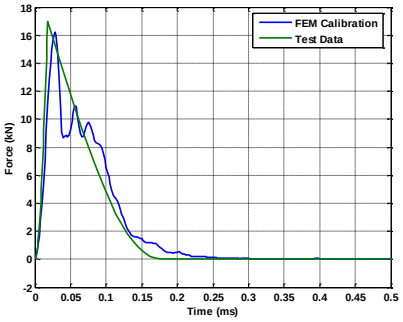


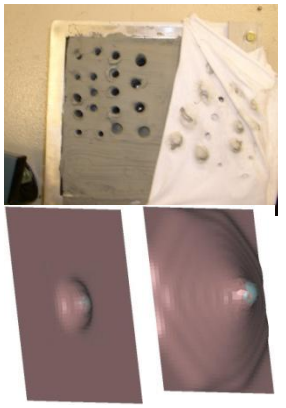


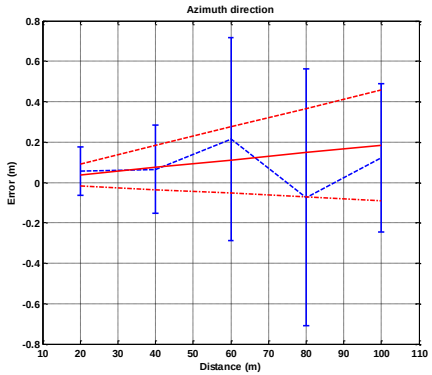


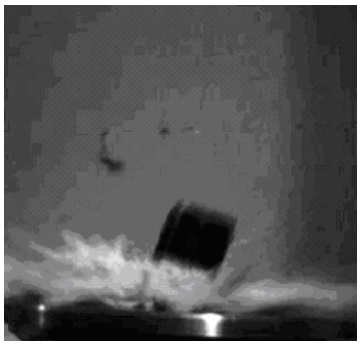
ATBM Exposure Characterization

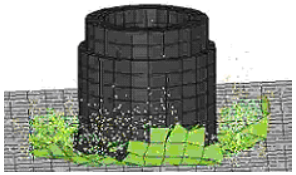


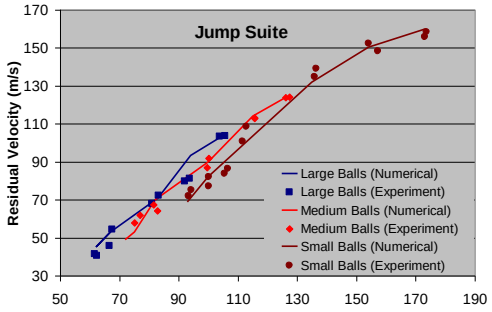






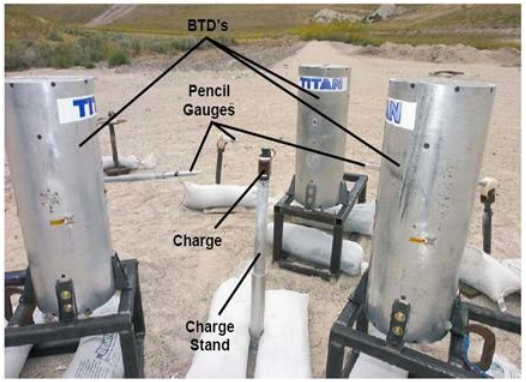


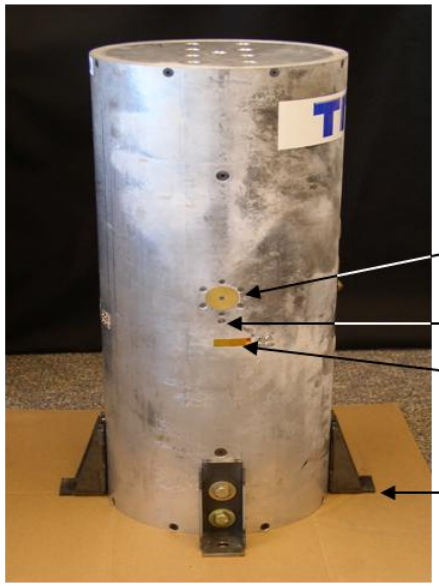




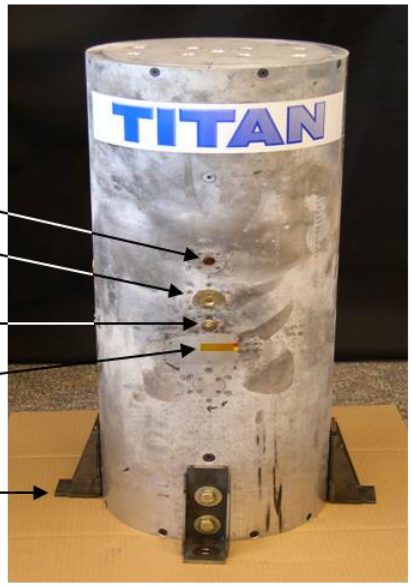
- For kinetic energy NLWs, test procedures and calibration models were developed to determine:
  - Air dragging: firing test
  - Accuracy: firing test
  - Dispersion: arena test
  - Impact characteristics (projectile FEM): static compression and dynamic impact tests
  - Penetration characteristics (V50, depth, p or penetration): penetration tests
  - Clothing mechanical and failure properties (Clothing FEM): clothing tests

Determine Exposure (Multi-Sensory Devices)





Right Side (270°)

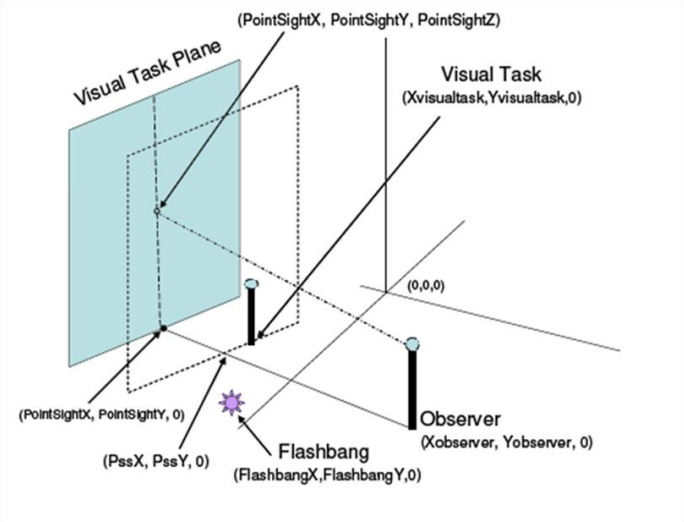


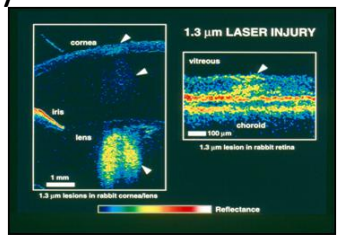
Front View (0°)

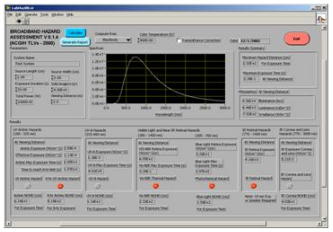
Force Sensor
Heat Flux Sensors
Pressure Sensors
Thermocouples
Mounting Feet

Body Response and Injury Correlation (Multi-Sensory Device)

- Optical Effects Model will assess flash-bang potential for inducing a flashblindness effect
- Thermal damage and broadband hazard model will predict probability of retinal and corneal damage to the eye
- Injury will predict probability of lung injury due to blast overpressure
- Burnsim will predict depth of burns identifying 1st, 2nd, and 3rd degree injuries
- Auditory will determine probability of ear pain, temporary and permanent threshold shifts (TTS and PTS), and eardrum rupture
- All of these models along with ATBM are integrated into the HE-MAP software for centralized, standardized, and efficient human effects analysis

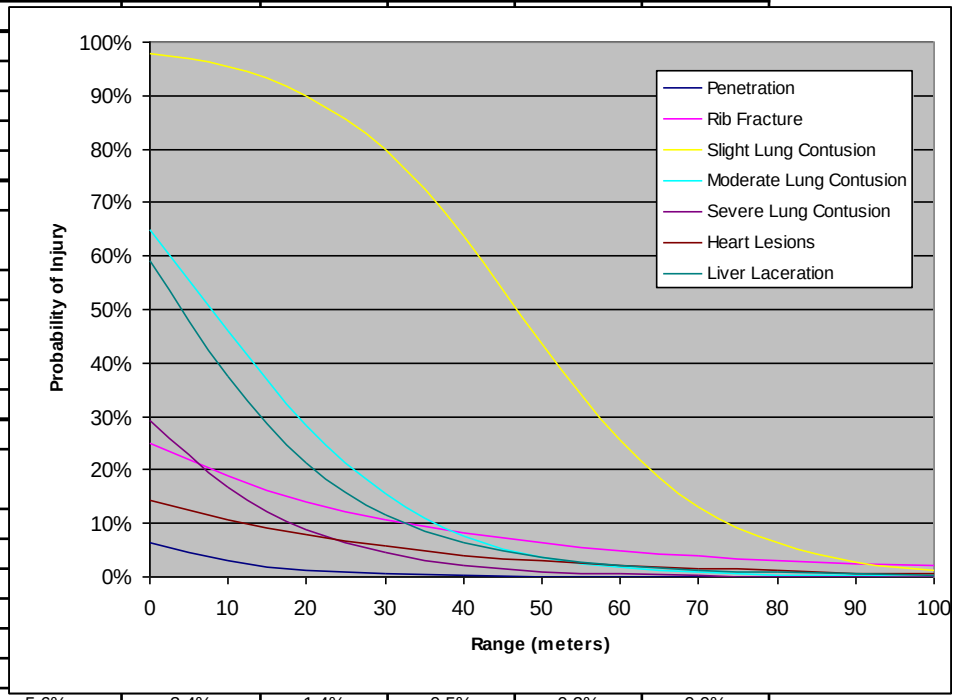




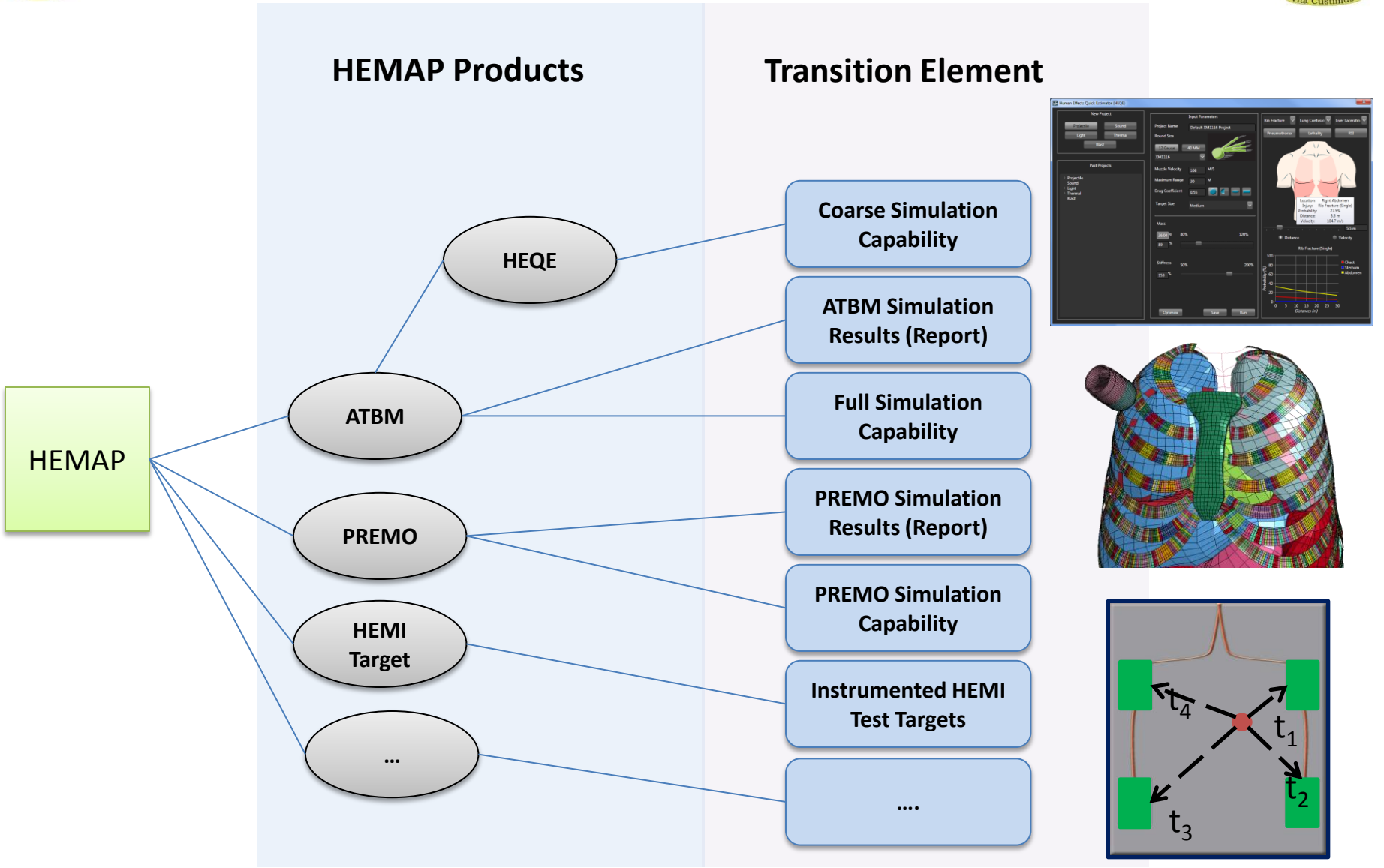


Typical ATBM Blunt Impact Results

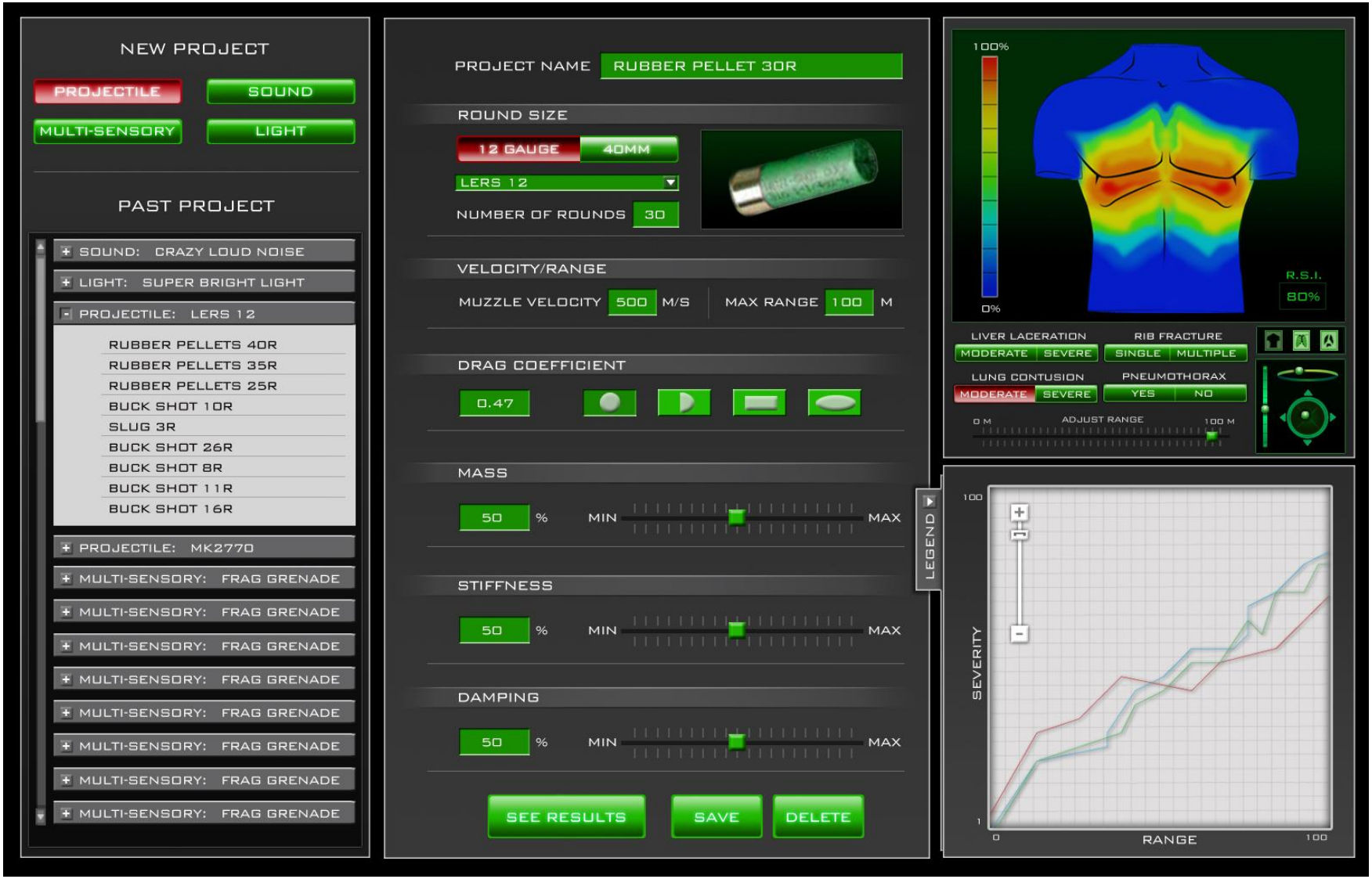
Impact Location	Impact Vel (m/s)	102.85	97.70	93.00	88.30	84.10	79.90	76.10	74.20
	Range (m)	10	20	30	40	50	60	70	75
Head	Skull Fracture	0.0%	0.0%	0.7%	0.7%	0.0%	1.4%	0.0%	2.1%
	Concussion	0.0%	0.0%	0.2%	0.2%	0.0%	0.3%	0.0%	0.5%
	SAH	0.0%	0.0%	0.2%	0.2%	0.0%	0.2%	0.0%	0.3%
	Contusion	0.0%	0.0%	0.4%	0.3%	0.0%	0.4%	0.0%	0.4%
	SDH	0.0%	0.0%						
Eye Socket	Corneal Abrasion	0.0%	0.0%						
	Retinal Damage	0.0%	0.0%						
	Lens Dislocation	0.0%	0.0%						
	Hyphema	0.0%	0.0%						
	Globe Rupture	0.0%	0.0%						
Thorax	Mild Lung Contusion	17.1%	18.3%						
	Moderate Lung Contusion	0.7%	0.6%						
	Severe Lung Contusion	0.0%	0.0%						
	Single Rib Fracture	5.4%	4.7%						
	Multiple Rib Fractures	0.0%	0.0%						
	Pneumothorax	0.5%	0.5%						
	Skin Penetration	28.7%	33.2%						
Sternum	Mild Lung Contusion	0.0%	0.0%						
	Moderate Lung Contusion	0.0%	0.0%						
	Severe Lung Contusion	0.0%	0.0%						
	Single Rib Fracture	0.0%	0.0%						
	Multiple Rib Fractures	0.0%	0.0%						
	Pneumothorax	0.0%	0.0%						
	Ventricular Fibrillation	0.0%	0.0%						
	AIS>4	0.9%	0.2%						
	Skin Penetration	26.7%	8.8%	5.6%	3.4%	1.4%	0.5%	0.2%	0.0%
Abdomen	Mild Liver Laceration	0.4%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	Moderate Liver Laceration	0.2%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	Severe Liver Laceration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Single Rib Fracture	6.1%	9.2%	4.8%	1.7%	0.7%	0.3%	0.4%	0.3%
	Multiple Rib Fractures	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Skin Penetration	10.9%	19.5%	12.2%	5.1%	2.1%	0.9%	0.8%	0.5%



HEMAP Transitions



Human Effects Quick Estimator



Industry Access to HE M&S Tools

- AFRL has been successful at developing CRADAs allowing Industry to have developmental rounds evaluated with Gov't M&S tools
  - Cost savings for Industry
  - Potential for design optimization
  - Same tools DoD will use to evaluate
  - Potential to use Industry-collected data as M&S inputs
  - M&S input parameters can be shared with Industry

- AFRL/JNLWD often utilize contract support to characterize human effects
  - Non-Disclosure Agreements (NDA's) are utilized

- NLW Human Effects M&S continues to be improved
  - Application/transition products are being developed
  - Reduces costs for analyses and potential to put products in hands of weapon developers

JNLWP Human Effects POCs

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Questions


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