

U.S. Army Evaluation Center

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Human Effects Modeling Analysis Program (HE-MAP)

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ITEA Symposium 2013
Sara Campbell



Agenda

- DoD Policy
- Background
- Justification/Intended Use of M&S
- Accreditation Assessment
- Limitations
- Accreditation Report Approval



DOD Policy

“ATEC will accredit models and simulations when their use may affect the evaluation of the performance or military utility of the System Under Test (SUT)” (ATEC Regulation 73-21).

DoDI 5000.02

“...Appropriate use of accredited **models and simulation** shall support Developmental T&E, Operational T&E, and Live Fire T&E.”

DoDD 5000.59

“...M&S applications used to support the major DoD decision-making organizations and processes...shall be accredited for that use by the DoD Component for its own forces and capabilities.”



HE-MAP Background

Created in 2008 by the Air Force Research Laboratory (AF/RL) Human Effectiveness Directorate , Human Effects Center of Excellence (HECOE)

Intent was to centralize and standardize human effects assessments by integrating and interfacing various bioeffects models for a variety of non-lethal stimuli.

HE-MAP allows for analysis of human effects from various non-lethal stimuli by running one model, as opposed to several.

Munition Background

Typical non-lethal blunt trauma munitions





Risk of Significant Injury (RSI)

Risk of Significant Injury (RSI) terminology has been inserted into non-lethal weapon capability development documents to provide a reasonable and measurable requirement for non-lethal weapon risk.

The risk of significant injury (RSI) is a probability-based assessment described by Department of Defense Instruction (DODI) 3000.1 as the likelihood of injury resulting in death, permanent injury, or requiring medical intervention beyond Health Care Capability Index 0 (HCC0) assuming a projectile impacts the person.

The Human Effects Center of Excellence has developed and implemented a methodology to translate predicted injuries, predicted by the Human Effects Modeling Analysis Program (HE-MAP), into the Health Care Capabilities (HCC's) that define RSI against the intended target only.



Justification/Intended Use of M&S

- It is not possible to test blunt trauma non-lethal munitions on human subjects
- M&S data is essential to assessment of these types of munitions



Health Care Capabilities Defined

HCC 0 (Limited First Responder Capability): The employment of immediate basic and advanced first-aid (self-aid or buddy aid) and basic combat life-saving skills.

HCC 1 (First Responder Capability): The employment of emergent care services (i.e., basic pre-hospital trauma life support to include paramedic emergency care, initial resuscitative and fluid therapy, and cardiac life support) and patient stabilization in preparation for evacuation to next HCC in the continuum of care.

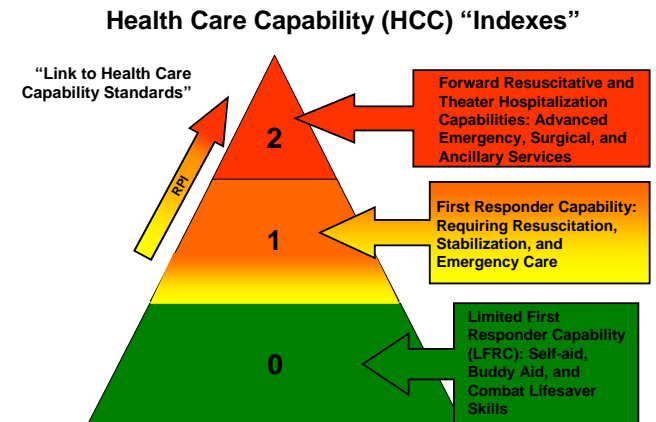
HCC 2 (Forward Resuscitative and Theater Hospitalization Capabilities): Forward resuscitative capability is characterized by the capacity to perform advanced emergency medical treatment as close to the point of injury as possible, to attain stabilization of the patient, and to achieve the most efficient use of life-and-limb saving medical treatment. Theater hospitalization capability involves purposely positioned hospitals with services not normally available at the lower levels of continuum of care. Capabilities can vary from theater to theater according to the regional infrastructure, operational area, and operational tempo.

Permanent Injury: Physical damage that permanently impairs physiological function that restricts employment and/or activities of a person for the rest of his/her life.

JNLWD RSI Definition

RSI Definition: Potential to directly cause permanent injury, death, or an injury requiring Health Care Capability (HCC) Index 1 (First Responder Capability)* or higher index treatment.

* HCC Index 1 (First Responder Capability) requires resuscitation, stabilization, and emergency care.



An injury is considered "significant" if it requires HCC level 1 or higher care.

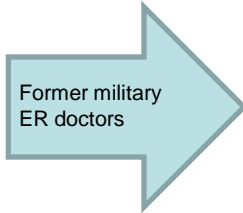
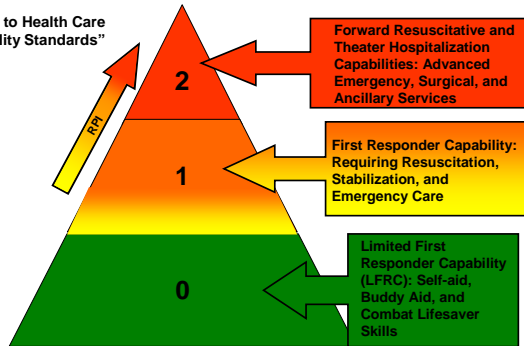
HECOE RSI Modeling

ATBM output: Physiological injuries from model output



Health Care Capability (HCC) "Indexes"

"Link to Health Care Capability Standards"



Injury Modality	HCC 0	HCC ≥ 1
Rib Fracture	80%	20%
Liver Laceration	70%	30%
1 st Degree Burn	0%	0%
2 nd Degree Burn	95%	5%
Retinal Lesion	85%	15%
Corneal Abrasion	90%	10%

Notional

RSI Conversion Matrix

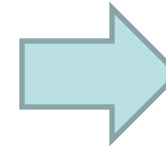


Table of RSIs of given body regions at various ranges



Notional HE-MAP Output

Impact Vel (m/s)	100	95	90	87	85	80	75	72
Range (m)	10	20	30	40	50	60	70	75
Head								
Skull Fracture	0.7%	0.6%	0.5%	0.6%	0.0%	1.4%	0.0%	3.1%
Concussion	0.0%	0.0%	0.2%	0.2%	0.0%	0.3%	0.0%	0.5%
SAH	0.6%	0.4%	0.2%	0.2%	0.0%	0.2%	0.0%	0.3%
Contusion	0.0%	0.0%	0.4%	0.2%	0.0%	0.4%	0.0%	0.8%
SDH	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eye Socket								
Corneal Abrasion	0.0%	0.0%	0.8%	0.5%	1.4%	0.7%	0.0%	0.0%
Retinal Damage	0.0%	0.0%	2.0%	1.5%	2.4%	0.9%	0.1%	0.0%
Lens Dislocation	0.0%	0.0%	0.0%	0.0%	1.4%	0.7%	0.0%	0.0%
Hyphema	0.0%	0.0%	0.0%	0.0%	1.9%	0.8%	0.1%	0.0%
Globe Rupture	0.0%	0.0%	0.0%	0.0%	1.1%	0.7%	0.0%	0.0%
Thorax								
Mild Lung Contusion	20.6%	22.3%	9.8%	4.2%	1.6%	1.0%	1.0%	0.8%
Moderate Lung Contusion	0.7%	0.6%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
Severe Lung Contusion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Single Rib Fracture	7.5%	5.7%	1.7%	1.1%	0.2%	0.1%	0.1%	0.1%
Multiple Rib Fractures	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pneumothorax	0.5%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
Skin Penetration	16.4%	12.6%	7.7%	4.8%	1.9%	1.8%	1.2%	1.1%
Sternum								
Mild Lung Contusion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%



Notional RSI output as a function of probability of shot

Range (m)	10	20	30	40	50	60	70	75
Head	0.0%	0.0%	0.4%	0.3%	0.0%	0.1%	0.0%	0.0%
Eyes	0.0%	0.0%	0.0%	0.0%	1.0%	0.5%	0.0%	0.0%
Right Thorax	3.6%	3.1%	2.4%	1.0%	0.5%	0.1%	0.1%	0.1%
Left Thorax	5.4%	4.8%	2.6%	1.1%	0.3%	0.2%	0.1%	0.1%
Sternum	2.5%	0.6%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
Right Abdomen	1.3%	1.8%	0.9%	0.3%	0.1%	0.1%	0.1%	0.0%
Left Abdomen	1.6%	1.8%	0.8%	0.6%	0.1%	0.1%	0.0%	0.0%
Mid Abdomen	3.9%	2.7%	0.0%	0.4%	0.1%	0.0%	0.0%	0.0%
Total Body RSI	18.3%	14.8%	7.3%	3.8%	2.2%	1.1%	0.3%	0.2%

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Accreditation Assessment

1) Can projectile characteristics and kinetic energy impulse be accurately represented? YES

- Projectile characteristics and kinetic energy impulse were validated.
- Impulse was calculated by numerically integrating the force data with respect to time.
- Model predictions compare favorably with test measurements.
- The velocity range of interest was not tested for the projectile, however adequate justification was provided to account the range discrepancy .



Accreditation Assessment

2) Can the human target and its physical response to blunt impact stimuli be accurately represented? YES

- The physical response of the human target was represented using ballistic gelatin.
- Use of ballistic gelatin is beneficial because the properties are very consistent when compared with animal tissue.
- Animal tissue has long been used as a comparison for human tissue penetration response.
- Using ballistic gel penetration data and animal tissue data for comparison, the physical response of the human target was accurately represented where modeled.



Accreditation Assessment

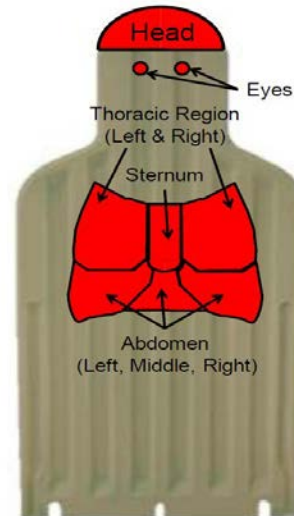
3) Is injury data being translated correctly into RSI for a single point target?

YES

- HECOIE has developed and implemented a methodology to translate predicted injuries, predicted by the Human Effects Modeling Analysis Program (HE-MAP), into the Health Care Capabilities (HCC's) that define RSI.
- Methodology involves creation of a translational matrix that bins individual injury modalities into the HCC's that define RSI.
- HECOIE accessed the expertise of the USAF medical specialty consultants and civilian ER trauma doctors who were asked to bin the various injuries into the HCC categories that define RSI.
- Completed matrix was used to calculate the probability that each injury modality constituted a RSI.
- The aggregate probability of RSI across all injury modalities was modeled.

Limitations

- 1) The HE-MAP does not predict blunt trauma injuries to the extremities, neck, face, and other areas, which are likely hit points for blunt trauma non-lethal weapons.
- 1) Contributions from these currently non-modeled areas will increase the predicted RSI for the projectile. Modeling coverage area is shown in red

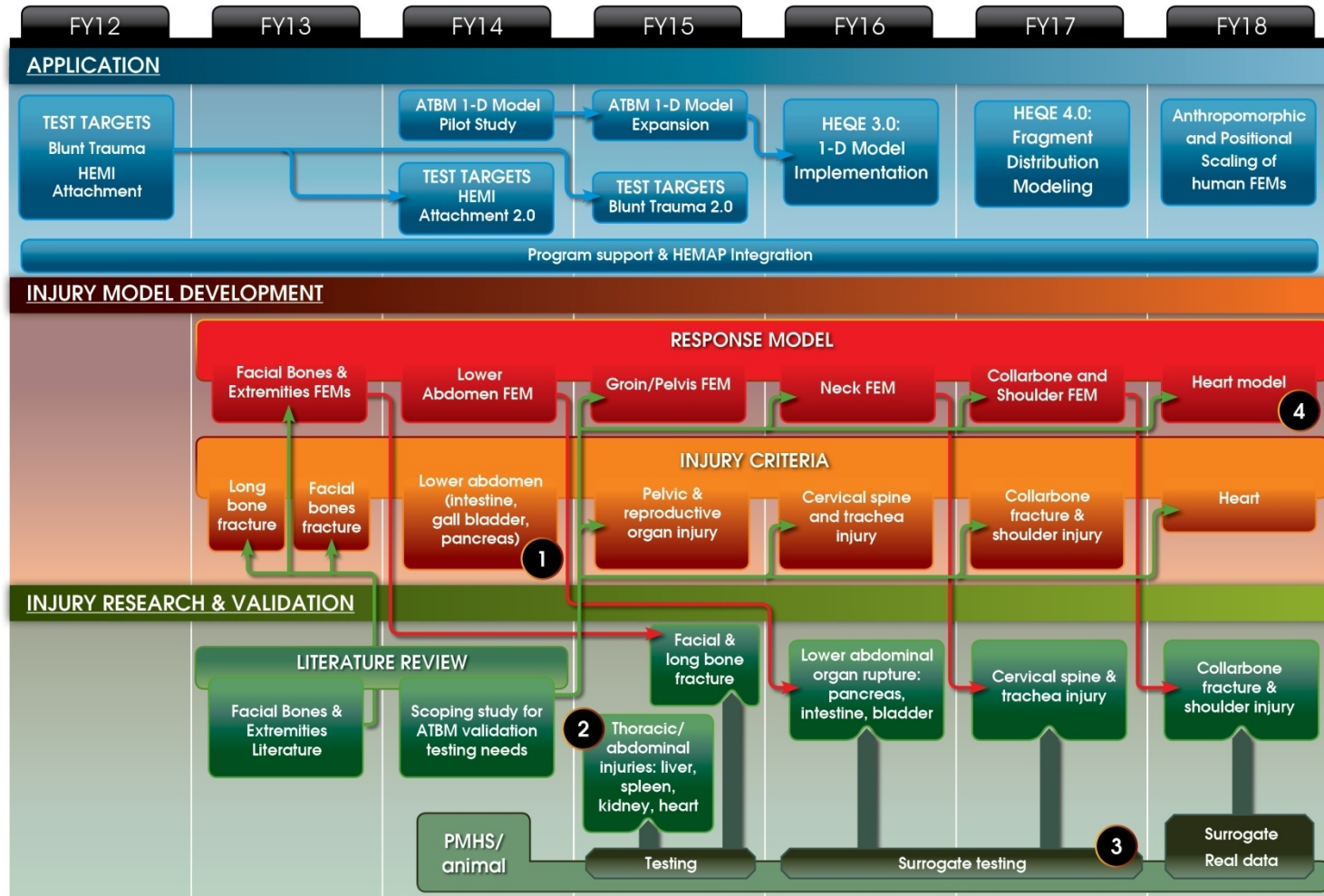




Limitations

- ATBM assumes the average female-male (60.1-90.1 Kg) weights in its calculation of RSI. The Torso FEM assumes 95% male. It should be noted that there is a possibility of different human effects if the target does not fall within average weight/height estimations.

HEMAP & ATBM Roadmap



From MRMC : (1) MRMC abdomen FE model enhancement; (2) MRMC animal test; (3) Hybrid III tests; (4) MRMC thorax FE model enhancement; (5) MRMC Behind Armor Blunt Trauma PMHS/animal test



Accreditation Report Approval

Accreditation report approval pending at AEC for first non-lethal munition evaluation application.

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Questions?