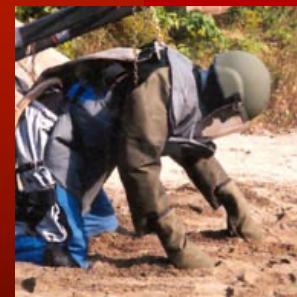
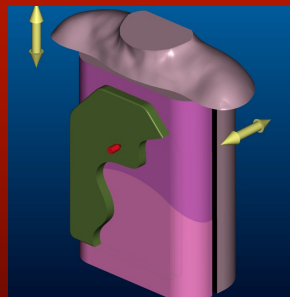


Performance Evaluation of Personal Protection Systems

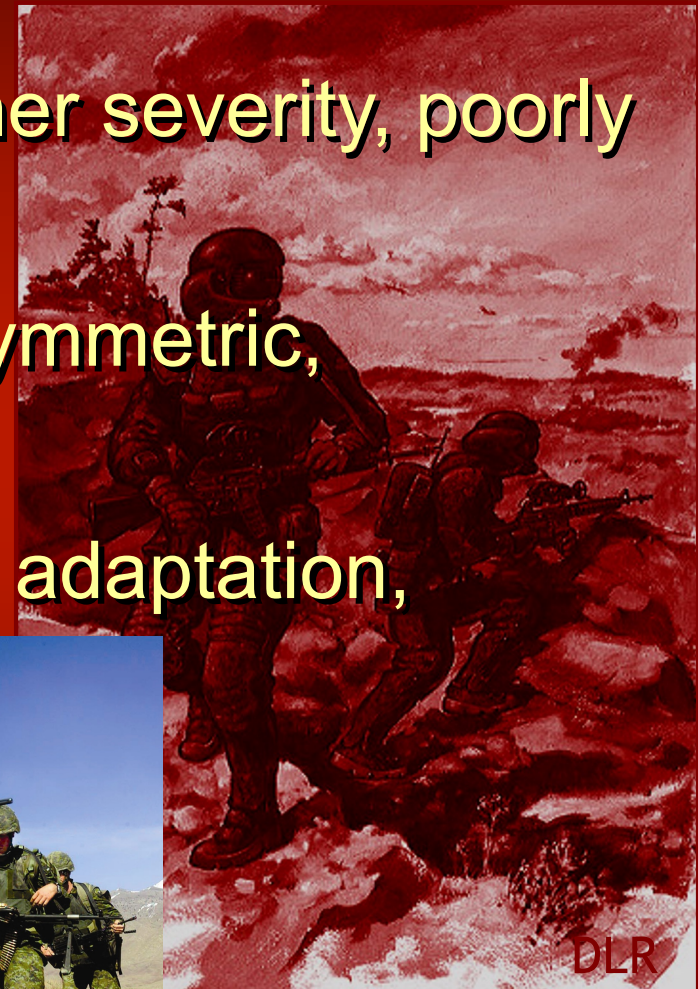
Nicholas Shewchenko
Biokinetics and Associates Ltd.

DEFENCE SECURITY INNOVATION
November 2005



Current and Future Environments

- Threats: evolving types, higher severity, poorly quantified
- Warfare transformations (asymmetric, unconventional)
- Army transformations (roles, adaptation, expansion, modernization)



Current and Future Environments

Threats & Env.

Injuries

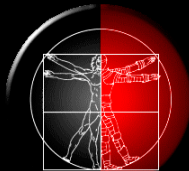
- Injuries reflect the threats and environment
- Changes can cause uncertainty in diagnosis, prevention and assessment of injuries
- Current injury patterns:
 - *New areas of injury*
 - *Injury types different*
 - *Injury severity range increased*

“Brain injuries lead Iraq war injuries”, UPI

“Key Iraq wound: Brain trauma”, US Today

“Canadian escapes injury in Kabul blast”, CBC

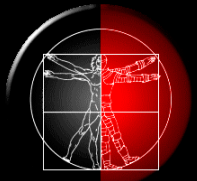
“New Helmet Doesn't Fit Iraq”, Wall Street Journal



Immediate Needs



Injury Risk Management (IRM)



IRM – Approach



- identification
- detection
- neutralization

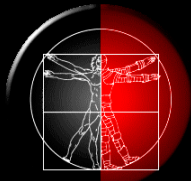
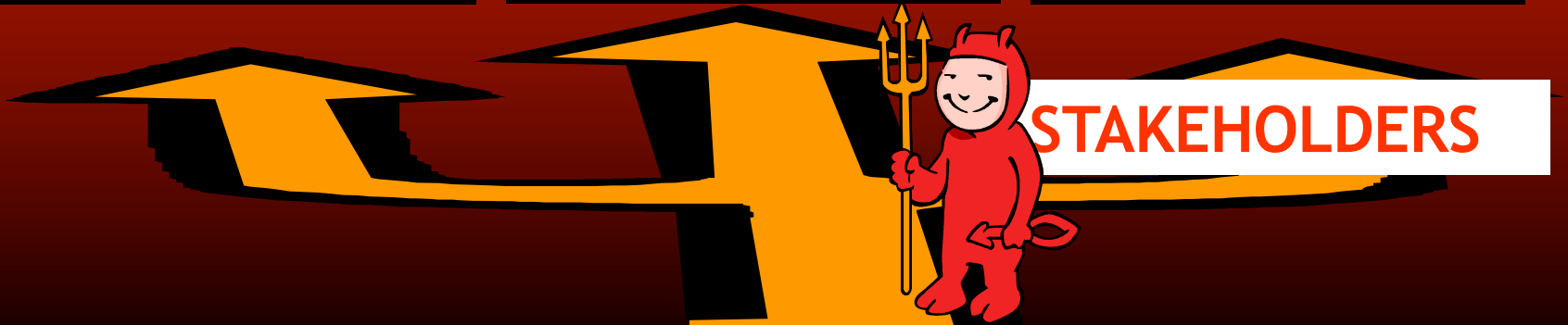
- protection
- intervention
- countermeasures

- injury diagnosis
- treatment
- rehabilitation

- test methods
- analysis methods
- protocols ...

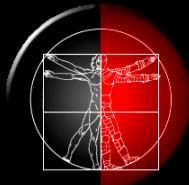
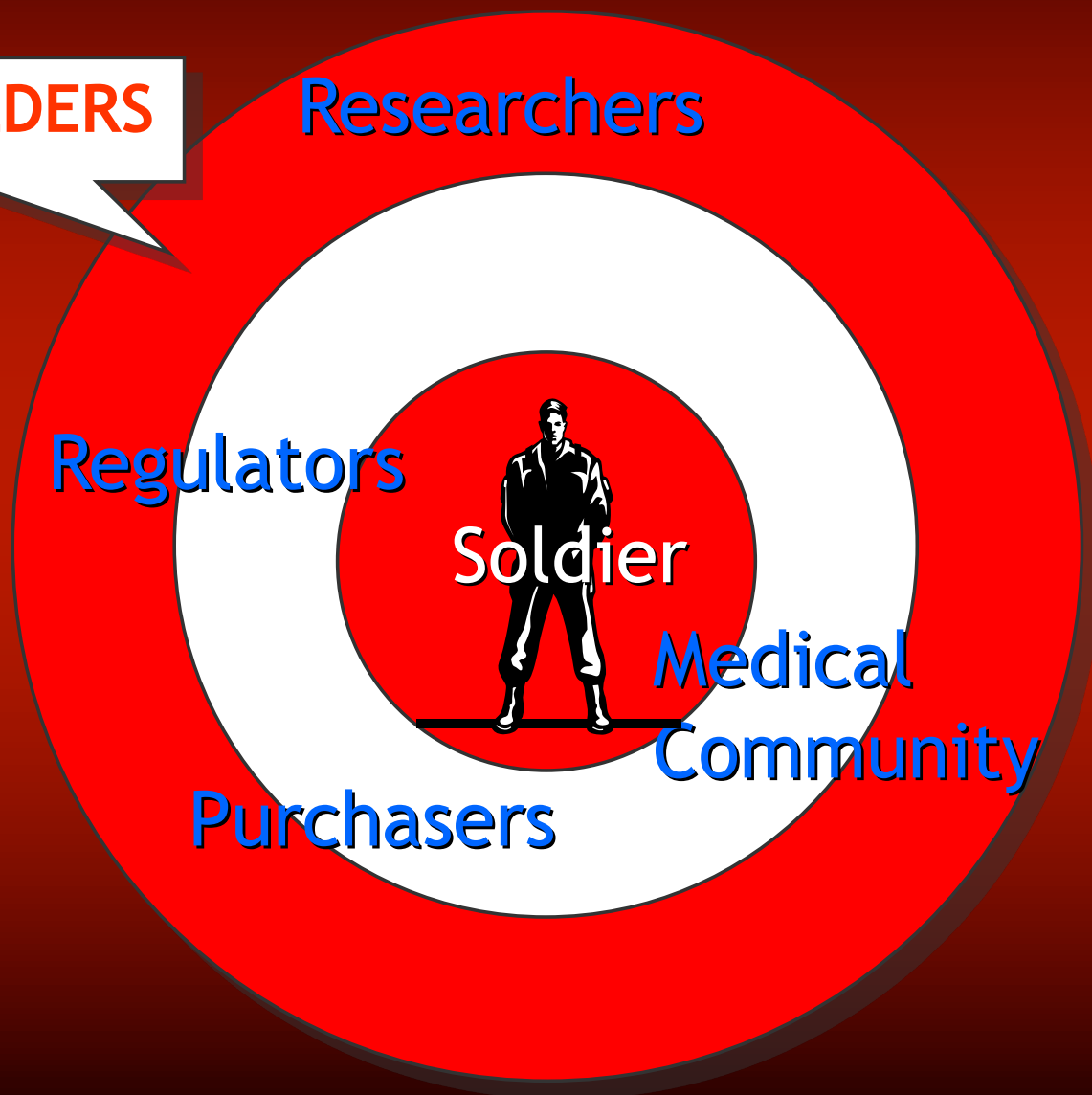
- body armour
- external protection ...

- training aids
- tools and skills
- processes ...



IRM – Stakeholders - Soldier Centric Perspective

STAKEHOLDERS



IRM - Threats

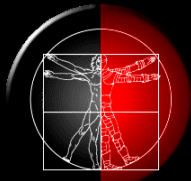


TYPES:

- Ballistic
- Conventional blast weapons
- IED Improvised Explosive Devices
- EBW Enhanced Blast Weapons
- Blunt trauma
- CBR Chem., Bio., Radiological
- Directed energy

EFFECTS:

- Overpressure
- Burns
- Blunt trauma
- Penetration
- Toxicity



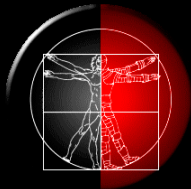
IRM - Injuries



- skull fractures
- closed head injuries
- soft tissue injuries

- rib/ sternum fractures
- soft tissue injuries (heart, lungs)

- calcaneus, tibia fx
- soft tissue disruption
- amputations



IRM – Priorities

INJURY

- *type, severity*
- *mechanisms*

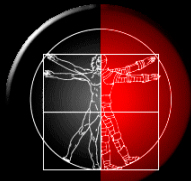
THREAT

- *type, severity*
- *incidence*

PRIORITIES

- *exposure vs. severity*
- *trade-offs vs. consequences*

PROTECTION REQUIREMENTS



IRM – Road Map

Injuries

Threats

Injury Mechanisms

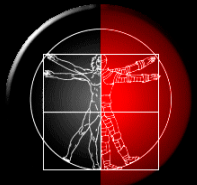
Injury Assessment
Methods

Surrogates

Injury Criteria

Performance &
Incapacitation

Protection Requirements



IRM – Surrogates for Injury Assessment

Surrogates:

- biological tissues*
- biological models*

dead & live animals, humans

- physical models*
- prediction models*

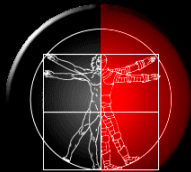
numerical, empirical, analytical

- hybrid models*



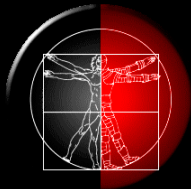
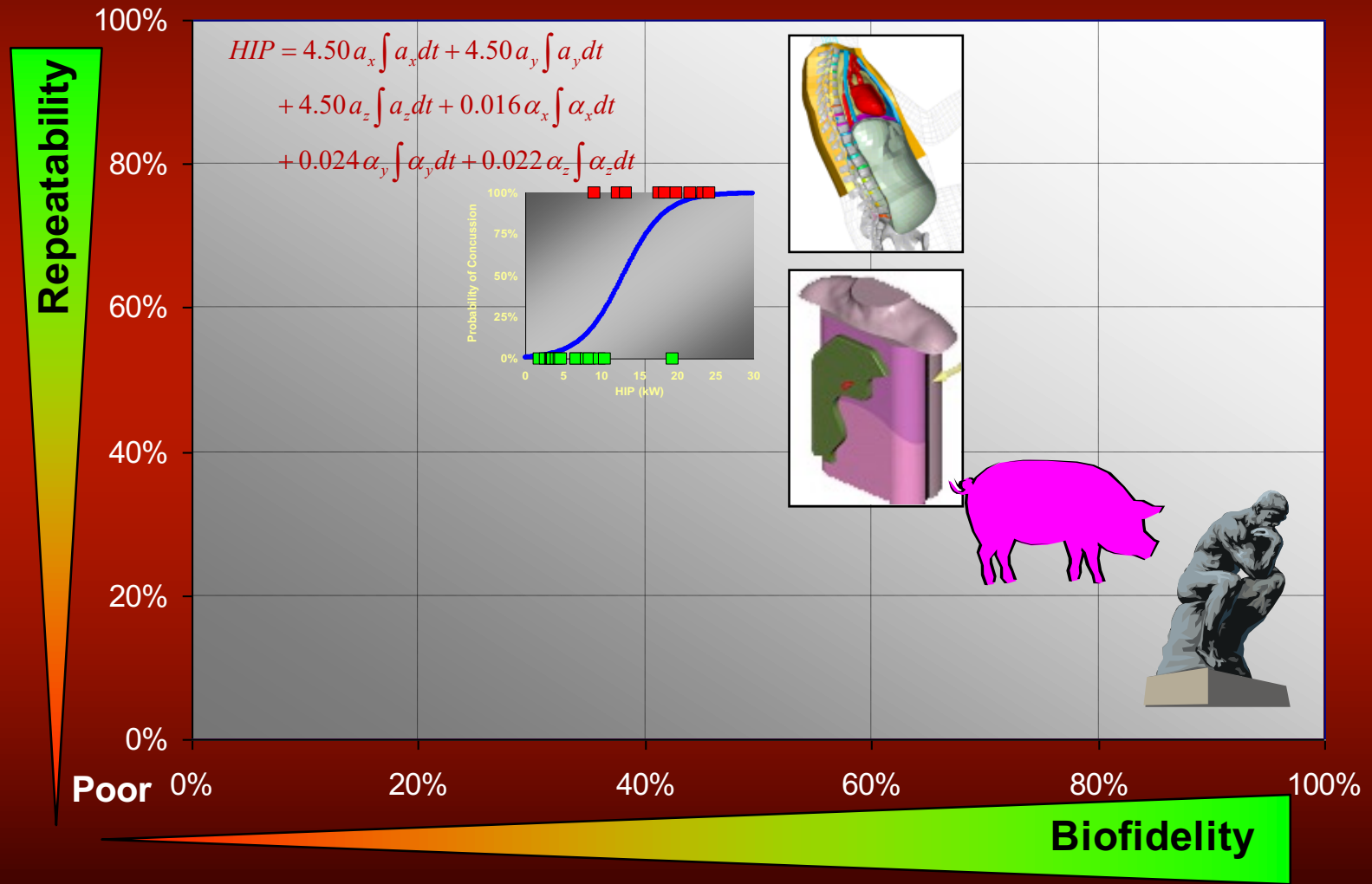
Balance of:

- *biofidelity*
- *injury prediction*
- *3Rs:*
 - repeatability*
 - reproducibility*
 - robustness*
- *\$\$ cost*
- *ease of:*
 - use*
 - maintenance*
 - calibration*
 - validation*



IRM – Surrogate Considerations

Surrogate Qualities



Ballistics Effects – Torso Surrogate



Injuries

Torso:

- penetration
- blunt trauma

Types:

- fractures of ribs, sternum
- rupture of heart and lungs

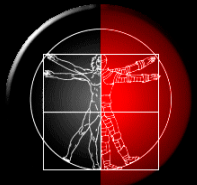
Threats

Projectiles:

- bullets
- fragments
- debris

Types:

- caliber
- speed
- mass
- shape
- material



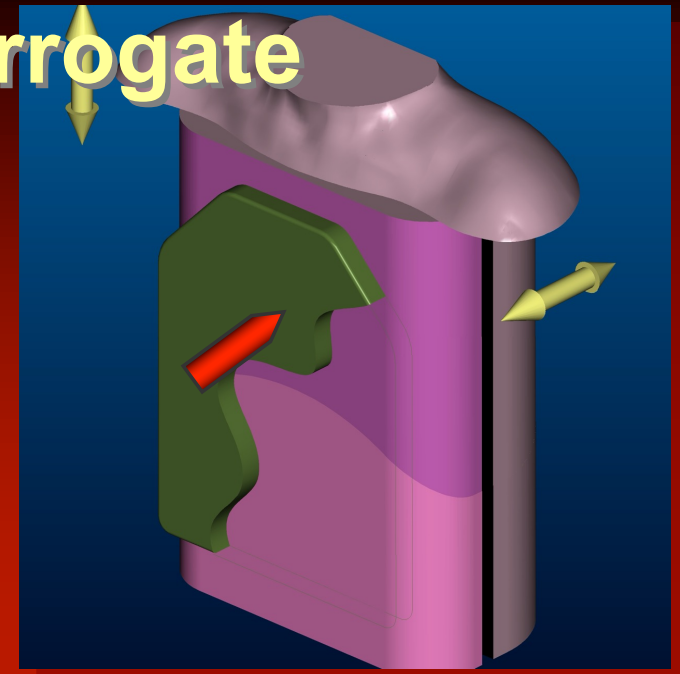
Ballistic Effects – Torso Surrogate

Torso Surrogate

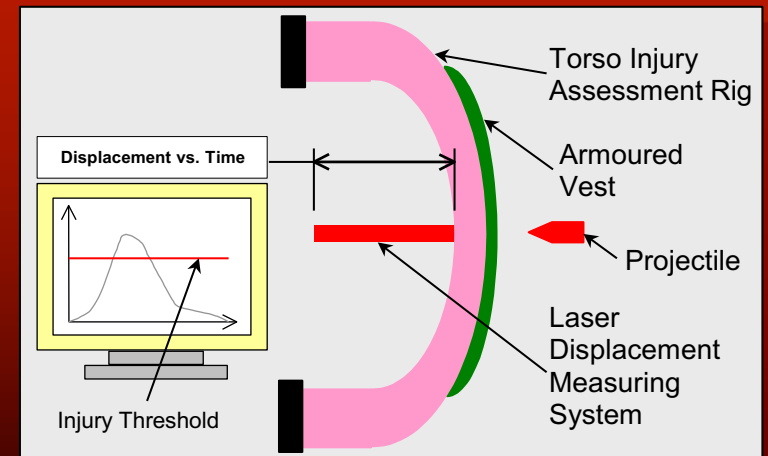
Torso Impact Membrane:

- biofidelic
(animals/cadavers)
- injury prediction criteria
- armour fits better
- 3R, low cost, ease of use
- used to assess soft and hard body armour

Research Ongoing:
DRDC Valcartier,
Biokinetics, TSWG



BABT Test Methodology



Injury Assessment of BABT



Ballistic Effects – Head Surrogate



Injuries

Head:

- penetration
- blunt trauma

Types:

- skull fx
- brain injury (acute/mild)
- global acceleration

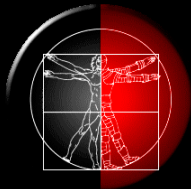
Threats

Projectiles:

- bullets
- fragments
- debris

Types:

- caliber
- speed
- mass
- shape
- material



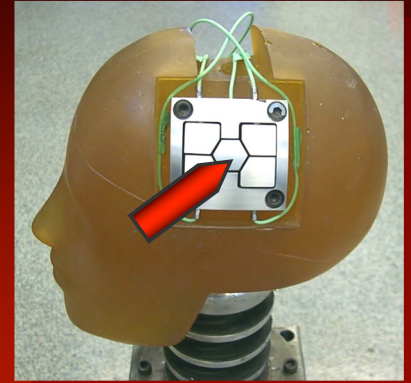
Ballistic Effects – Head Surrogate

Head Surrogate

Load Sensing Headform:

- biofidelic with transfer function (cadaver vs dummy)
- injury prediction criteria
- used to assess ballistic helmet performance

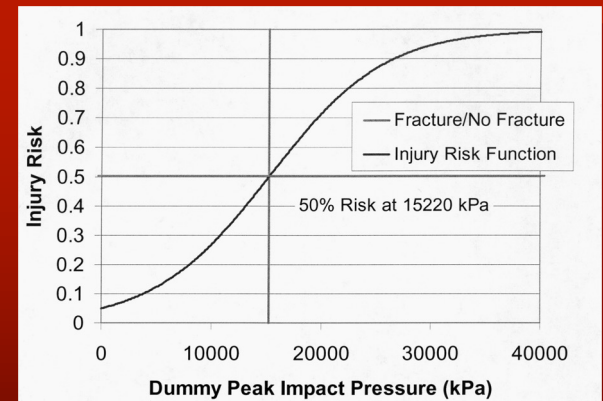
-Research Ongoing:
DRDC Valcartier,
Biokinetics, TSWG



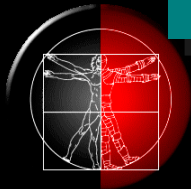
Skull Pressure Measurement System



Test Methodology



Injury risk based on skull pressure



AP Mine Effects – Leg Surrogate



Injuries

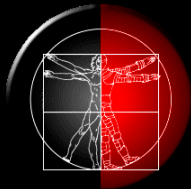
Lower Leg:
-blast, load
transmission,
acceleration

Types:

- fx of heel,
ankle, tibia
- soft tissue
disruption
- infections

Threats

AP Mines:
-blast
-fragments
-soil and
debris ejecta

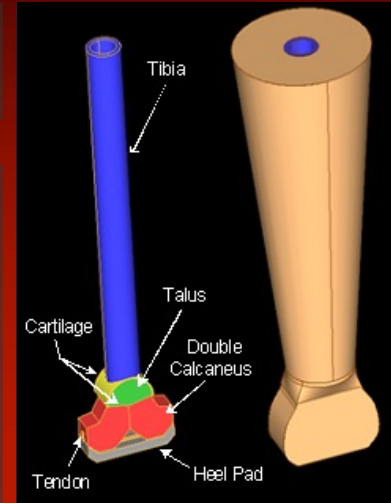


AP Mine Effects – Leg Surrogate

Lower Leg Surrogate

Complex Lower Leg (CLL):

- represents skeletal and soft tissue disruption
- can be related to injury assessments
- recognized by the NATO HFM-089 / TG-024
- used to assess footwear
- Research Ongoing: DRDC Valcartier



CLL bone and flesh



Boot evaluation

AP mine blast with FSL



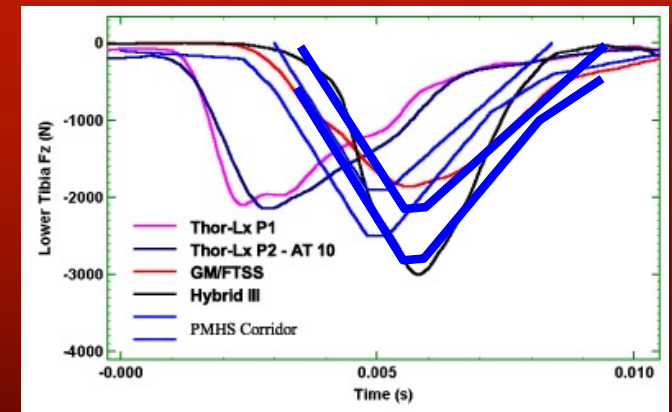
AV Mine Blast Effects – Leg Surrogates

Lower Leg Surrogates

Mechanical Legs:

- biofidelic under impact conditions
- can be related to impact injury criteria
- used to assess loading

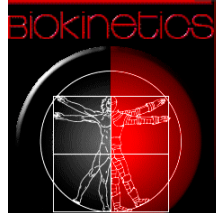
-Research Ongoing:
DRDC Valcartier



Courtesy of WTD 91

CLL on Hybrid III for AV
mine blast testing

Surrogate lower legs and
biofidelity corridors



Blast Effects – Head & Torso Surrogates



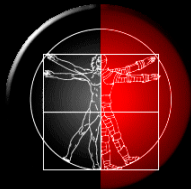
Injuries

Head&Torso:
-overpressure
-fragments
-blunt
trauma
-acceleration
-thermal
loads

Threats

EBW
Enhanced
Blast
Weapons

-sustained
pressure
-distance
-complex vs
free field



Blast Effects – Head & Torso Surrogates

Blast Surrogate

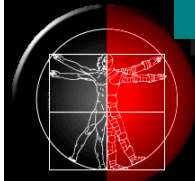
MABIL:

- head and torso to study blast loading
- compliments Hybrid III to assess blunt trauma and acceleration effects
- used to rank PPE
- Research Ongoing:
DRDC Valcartier,
Biokinetics



Mannequin for Assessment of Blast Incapacitation and Lethality

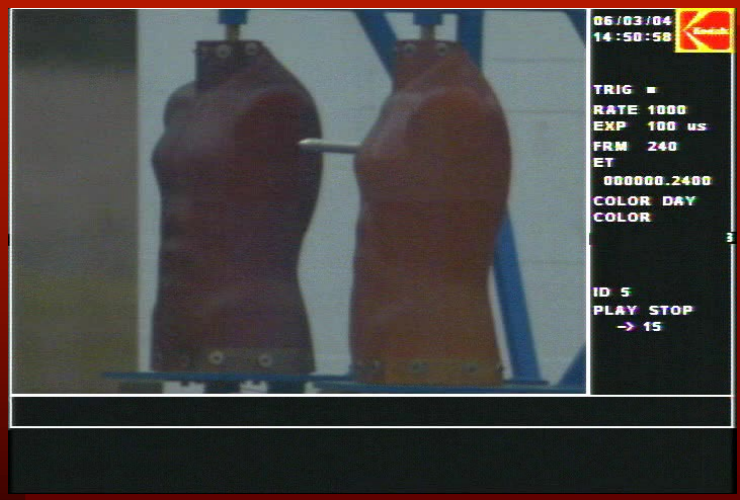
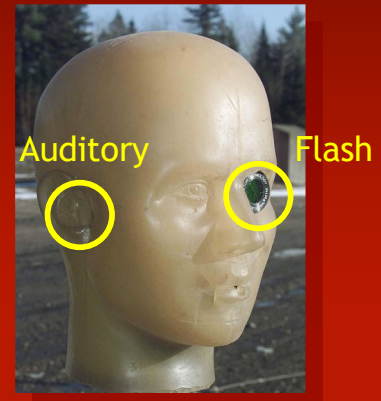
Characterization of EBW threat



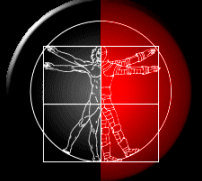
Blast Effects – Head & Torso Surrogate

MABIL

MABIL head used to measure peak pressure and impulse + optical.

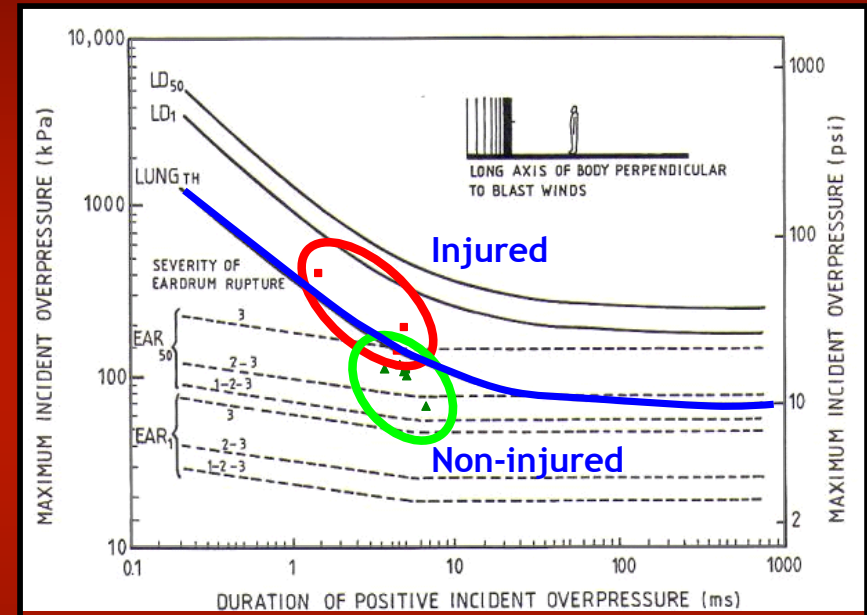
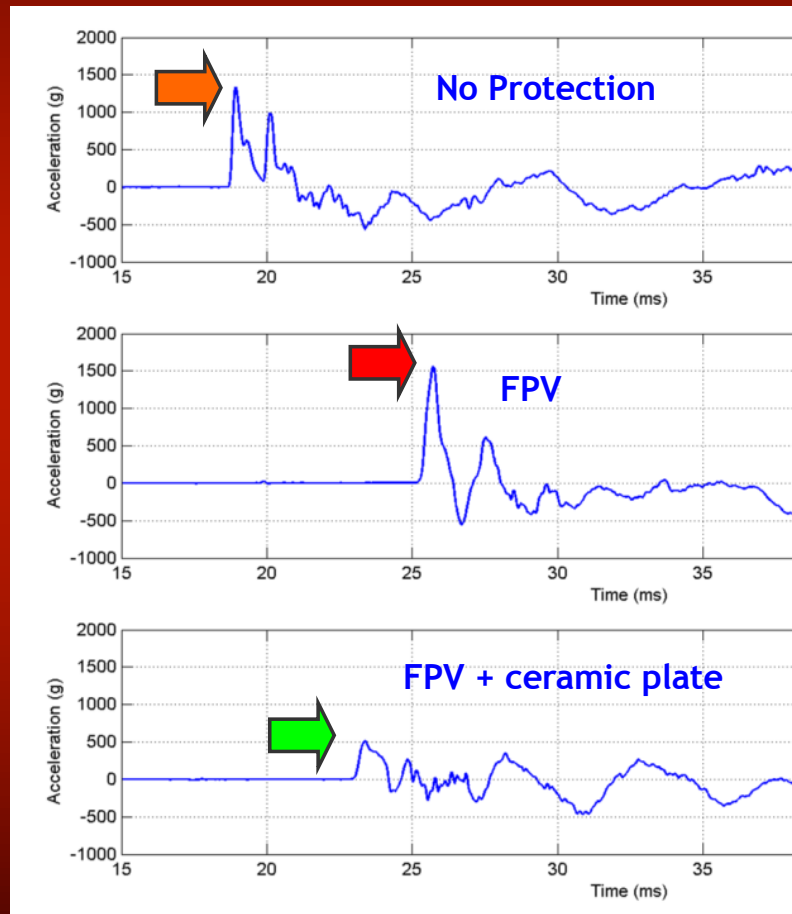


MABIL torso used to measure chest wall acceleration and pressure for injury assessment.



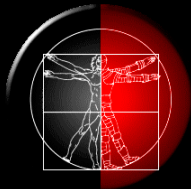
Blast Effects – Head & Torso Surrogate

MABIL



Prediction of lung injury from pressure measurements.

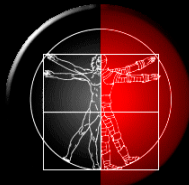
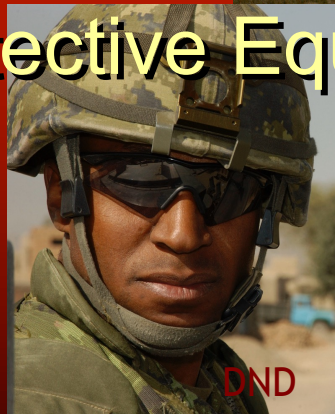
MABIL torso response to blast loading



IRM – Protective System Evaluation

Protection Requirements

- Threats Defined
- Test Methods
- Surrogates
- Performance Requirements
- Protective Equipment Development



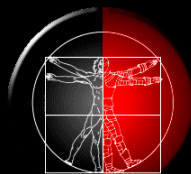
Evaluation of Protective Equipment

- Results of research feeding into several DRDC sponsored programs:

- *head/torso/leg injury assessment and protection*
- *Surrogate developments
CLL, MABIL, Ballistic Headform,
TIM, Blast Headform*
- *Technology Demonstration Programs*



Biokinetics



Questions?

