Soldier Systems Technology Roadmap Survivability/Sustainability/Mobility Workshop

Blast/Ballistic/Impact Protection :

Lessons Learned and Technical Challenges

DRDC Valcartier SL 2010-229

By Kevin Williams,

Defence Scientist, Weapons Effects and Protection Section

DRDC Valcartier

May 12-13, 2010

Fairmont Château Laurier
Ottawa, Ont.

Government of Canada | Gouvernement du Canada

Canada

OUTLINE

- Priorities for Protection
- Impact on PPE Design
- Challenges for
  - Soft Armour Design
  - Composite Armour Design
  - Bullet Resistant Plate Design
  - Other Material Options
  - Modular Armour Systems
  - Overpressure Protection
- Evolution of Test Methodologies
- Conclusions

Priorities for Protection

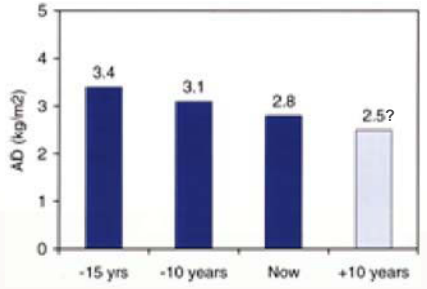
- PPE is the last resort for survivability
- Small arms
  - Proliferation of AP (including WC) and high calibre threats
  - Wider access to better weapons/sights resulting in increased accuracy of fire in some theatres of operation
- IEDs
  - Apparent shift in injury pattern to unprotected areas because of the performance of current PPE
  - Fragmentation dominates for exposed personnel
  - Blunt trauma from impacts/projection dominates for vehicle occupants
  - Primary blast injury does not appear to be a driver at this point
    - May change rapidly with an evolution of the threat
- Edged weapons / stab
  - Possible future threat ?
  - Generally not considered in military body armour
- Lower weight, lower weight, lower weight… (and more protection/coverage!)

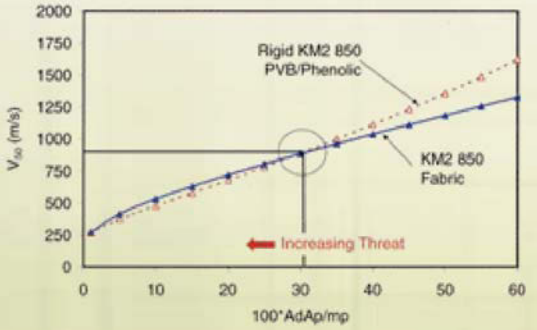
Impact on PPE Design

- Small Arms
  - Multi-hit requirements are being tightened
  - Move from Level III+ to full WC AP implies significant increase in AD and hence plate mass and cost with current material technologies
  - Management of BABT becoming an even more important driver in hard armour design
  - Requirement for greater hard armour coverage for some theatres of operation
- IEDs
  - Greater armour coverage (but at same or ideally lower weight)
  - Increased performance (but at same or ideally lower weight)
  - BABT mitigation can still be a requirement for soft armour
  - Increasing requirement for impact protection
- Edged weapons / stab
  - Competing requirements with fragment protection for soft armour
- Modularity
  - Mission / role specific balance of protection requirements vs physiological burden

Design and Material Challenges
Soft Armour

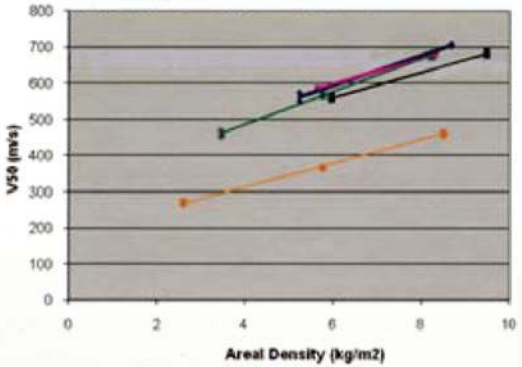
- Competing demands for more coverage / protection and lower system weight
- Soft armour performance continues to improve so there are avenues to increase coverage
  - But not enough to achieve desired coverage at current protection levels
  - As AD decreases, inertial effects become more important
- Focus additional coverage on improving injury outcome / quality of life rather than survivability?
  - Not necessarily easy decisions to make
  - Need to develop/improve the tools used to make these choices
- As required protection level increases, laminate armour is more efficient than soft armour
  - Important human factors considerations





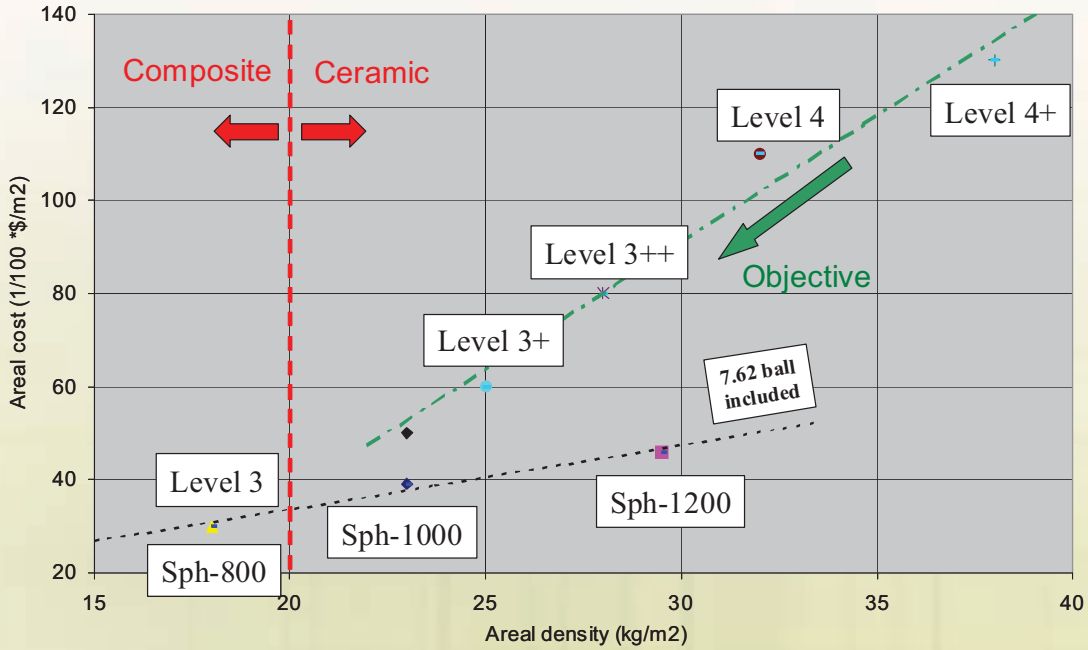
Design and Material Challenges
Composite Armour

- Advances in fibre technologies and thermoplastic base armour laminates allowing potentially significant weight savings in composite armour components
  - Further optimization of these systems likely possible
- However, as weight / thickness of ballistic protection systems decrease, structural performance requirements begin to dominate design
  - Full potential for weight savings, based on ballistic performance, may not be realized
  - New stiffening strategies
  - Review requirements for crush / stiffness / increased impact protection?



Design and Material Challenges
Bullet Resistant Armour

- Improvements in ceramic and composite material technologies allowing thinner / lighter plates for the same protection
  - Still a clear threshold in AD between non-AP and AP
- Durability of the plate increasingly drives design
- Combined steel and WC core protection is a challenge
- HF issues limit increased coverage
- New requirements for helmets



Design and Material Challenges
Other Material Options

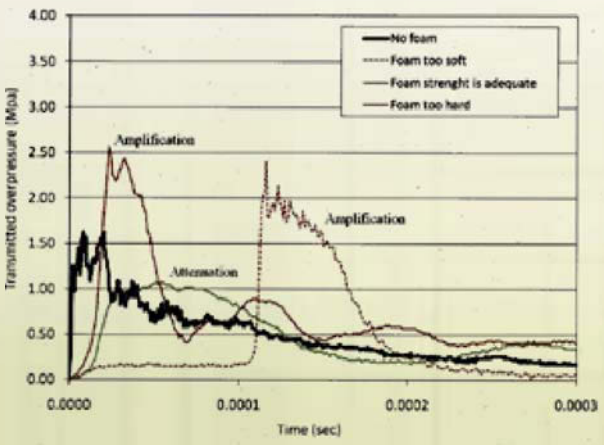
- Multi-function materials to reduce soldier system weight and/or provide weight budget for more protection
  - Soldier has to wear the armour to get the functionality of the imbedded system
- Transparent armour
  - Least efficient ballistic protection of the soldier system
  - Improving scratch resistance and anti-fog are a priority
- *'Reactive'* armour
  - E.g. highly strain rate sensitive (e.g. shear-thickening fluids, foams) and piezo-electric materials
  - Response time and structural properties are an issue for ballistic/blast protection
  - Early days
- Nanofibres

Design and Material Challenges
Modular Armour Systems

- In the context of an integrated soldier system, modularity is becoming a defacto requirement
- Proper integration of what would otherwise be add-on armour components
  - Requires forethought in the design and full understanding of armour performance / evolution over the service life of the system
- Can also apply to splitting existing protective components to allow tailored protection level for role / mission
  - E.g. CVCMH vs. CG634
  - Added functionality comes at a cost of system mass (no free lunch)
- Other important factors to consider
  - Stowage
  - Logistics
  - Ease of use / assembly

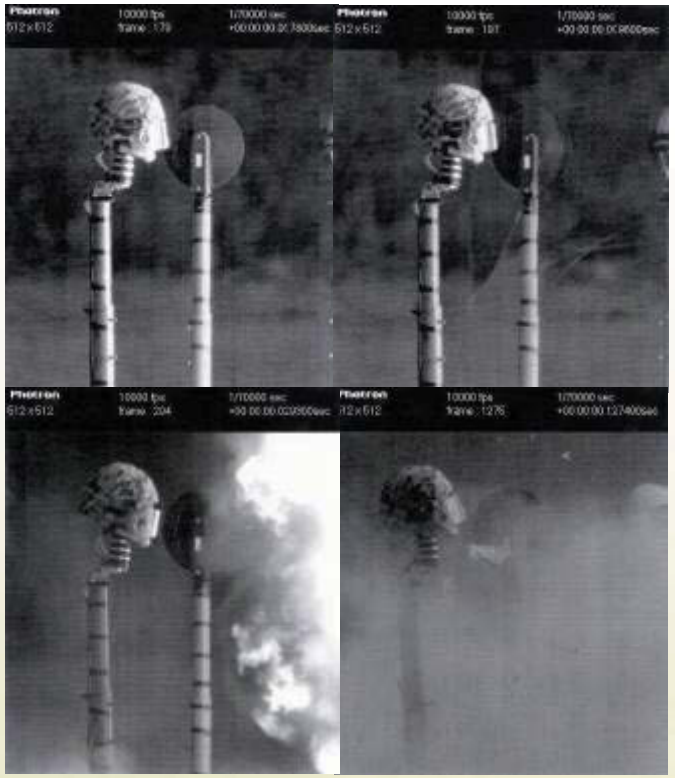
Design and Material Challenges
Overpressure Protection

- Ear Protection
  - Damage to inner ear occurs at low overpressure,
  - Protection can be achieved relatively easily with earplugs
- Thoracic protection
  - Air-containing organs are the most vulnerable to overpressure
  - Rigid and relatively heavy ballistic plate can reduce the loading on the lungs (in this case heavier is better!)
  - Loading on the body comes from all directions therefore greater coverage by rigid armour may be needed (e.g. side plates) to fully protect lungs
  - Can increase protection using rigid ballistic plate with a compressible backing
    - Tailored to a relatively narrow range of loading
- An important requirement for any PPE is that it remain in place following exposure to a blast



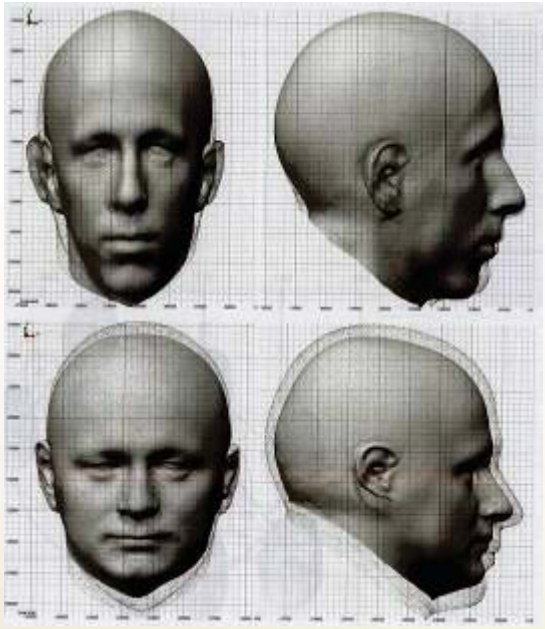
Design and Material Challenges
Overpressure Protection

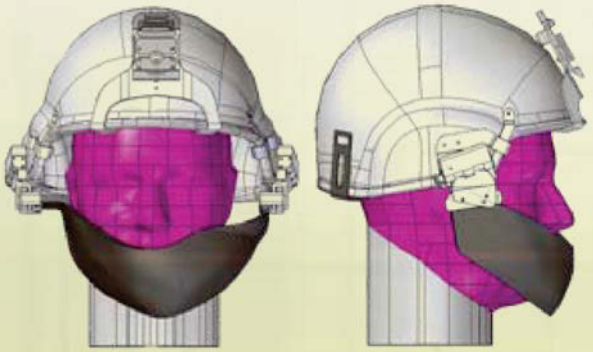
- Head Protection
  - No consensus on a mechanisms of injury for direct overpressure effects on the CNS
    - Most assessments currently based on induced head acceleration
  - Coverage and liner / suspension system are the two components that most strongly influence energy transfer to the head
  - Optimization of a liner for impact does not necessarily optimize for reducing induced head acceleration from exposure to blast
  - Coverage such as the provision of a face shield, even a short visor, decreases induced loading to the head



Design and Material Challenges
Human Factors Bounds to PPE Evolution

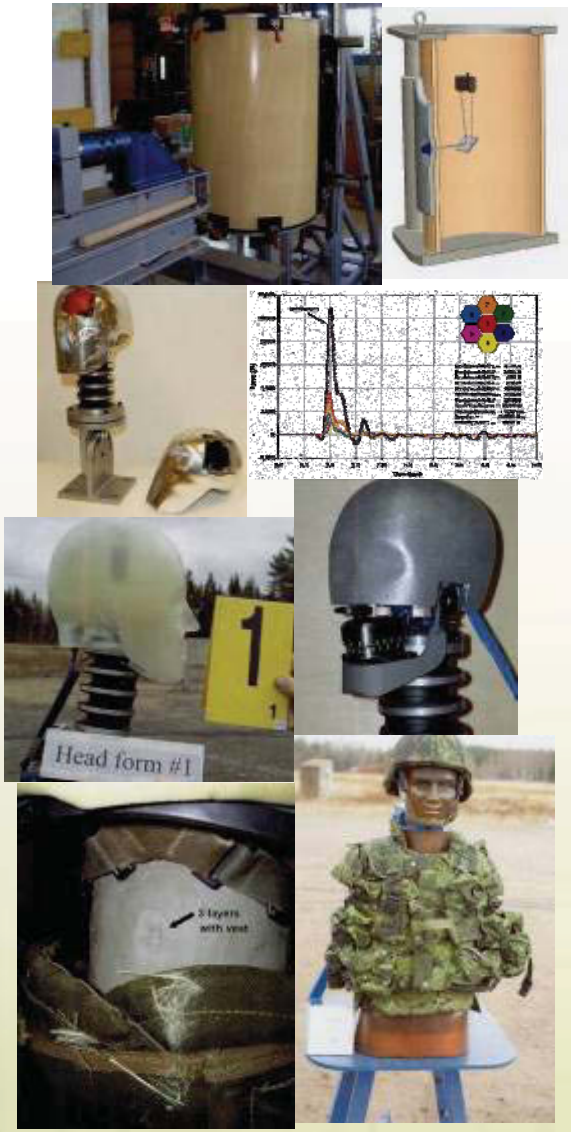
- Human factors engineering requirements drive acceptable coverage
  - Soldier acceptance of further increases in coverage / protection levels dictated by:
    - Range-of-motion, field of view, thermal comfort, role/mission, and compatibility with the rest of the soldier system dictate
  - Move to more rigid solutions makes soldier acceptance much more difficult to achieve
  - Facial protection in particular requires a level of customization to fit the range of facial geometries in the population of users
  - Design of increase protection / coverage ideally requires continuous feedback from the user throughout the design process
  - The best protection system that the soldier will not / cannot wear gives no protection at all





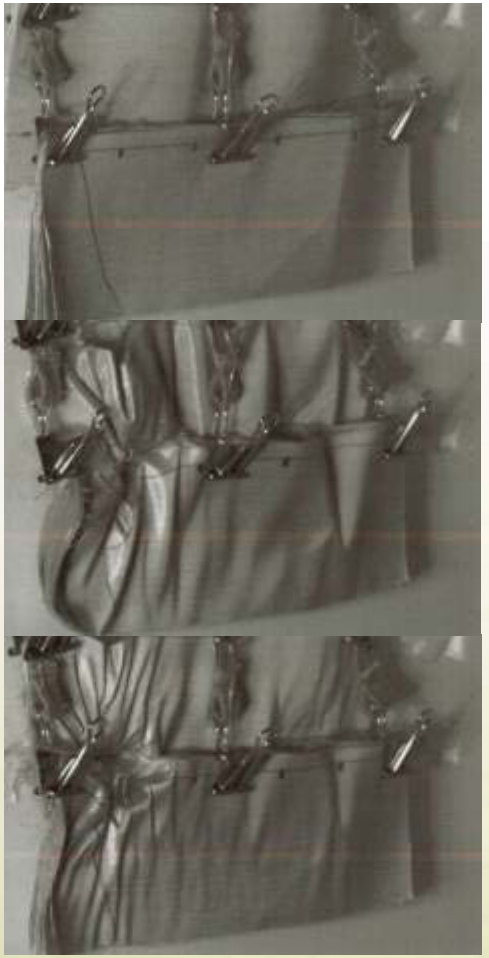
Evolution of Test Methodologies

- No single surrogate covers all threats and injury outcomes
- New surrogates have been developed to improve assessment of BABT performance of vests, plates, and helmets
  - Biofidelic / performance linked to injury outcome
  - Appropriate to military threats / PPE
  - Assist design / optimization
- Surrogates also available for the assessment of PPE performance in mitigating primary blast injury
  - Focus of recent international effort to develop / validate thoracic surrogates as well as best practices for their application
  - Understanding of the injury mechanism is a barrier to development of new predictive surrogates for head injuries
  - Requirements for greater armour coverage are outpacing the development of appropriate assessment methodologies



Evolution of Test Methodologies

- Modular systems typically involve smaller and overlapping ballistic components
  - Performance of narrow woven and laminated armour systems can be different than the large panels
  - STANAG 2920 Edition 4 will start to address this aspect of PPE design
- Burst / multi-hit inertial effects on protective system components
  - Some laboratory work but gap in current test standards
- Stab / edged weapons
  - Test methodologies well established in law enforcement
- Transitioning new laboratory test methodology to formal test standards can be challenging and can take time



Conclusions

- Advances in materials technologies are providing some options for reduced weight/increased coverage
- Modularity is an avenue to allow protection level to be adapted to a given mission

But

- No clear indication of a major leap forward in materials performance
- Increased coverage will have to be focused on critical / vulnerable areas because the mass associated with large areas of additional protection will not be offset by improvements in materials technologies

Conclusions

- Injury based test methodologies need to keep pace with evolving coverage and increasingly detailed injury mitigation requirements
- As material technologies improve for ballistic protection, other requirements emerge as the dominant design drivers reducing potential weight savings
- Human factors engineering requirements provide significant challenges to soldier acceptance of new protection systems


Canada