

**Soldier Systems TRM
Visioning Workshop**

**Shield/Survivability
& Personal Protective Equipment (PPE)
Vision and Future Requirements**
Gatineau, QC, 16-17 June 2009

**Capt R.T. Montague
DLR-5-10-2**

uniform, lightweight protective clothes, flexible displays, wireless network, biometric identification, event dr, info, posititon & motion sensors, pda tags, digital identif, 5 YRS, wearable power, membranes food/water/air, smart textiles, wearabe rf/ric/opto/acoustic health sensors, fluidic sors, tissue, nutraceuticals, solar cell in-foil, μ -fue

Government of Canada Gouvernement du Canada

Shield - Scope

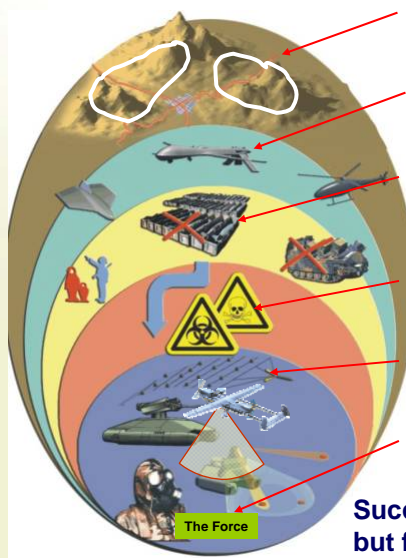
- Protection of soldiers & non-combatants, (platforms, systems, and sustainment assets) against physical and cognitive effects
- Protection of Friendly Information and the information products of the entire range of C4ISR processes
- Protection of Morale and Well Being (with a particular focus on the maintenance of a sense of mission legitimacy, as well as coalition integrity)

Shield Function vs Force Protection

- “Shield”: Shield is a layered, integrated and fully dimensional Operational Function that seeks to prevent any impact on friendly forces *and neutrals* across the physical, moral, and informational planes that could affect survivability, freedom of action *or mission success*
- “Force Protection”: all measures taken to contribute to mission success by preserving freedom of action and operational effectiveness through managing risk and minimizing vulnerabilities to personnel, information, material, facilities, and activities from all threats

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Shield Rules

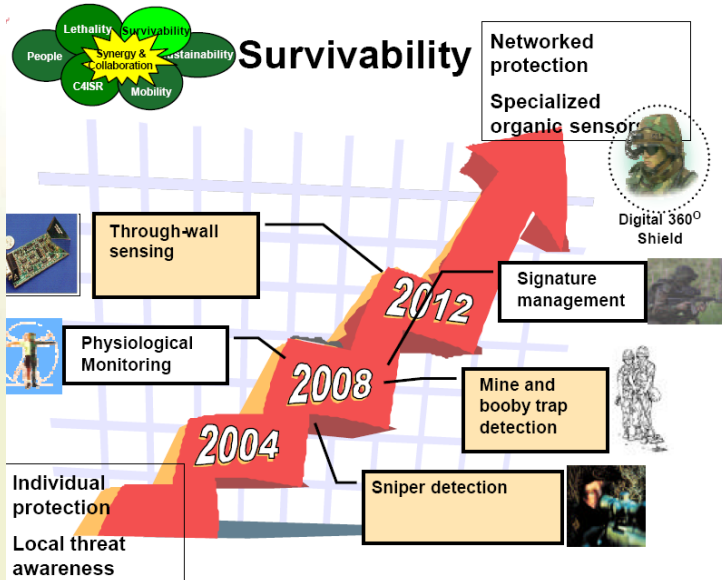


- **PREDICT** ACTIONS AND CIRCUMSTANCES THAT COULD THREATEN THE FORCE **COMMAND**
- USE ISR ASSETS FOR EARLY **DETECTION** OF THREATS AND ESTABLISH SURVEILLANCE **SENSE**
- ACT EARLY TO **PREVENT** POTENTIAL THREATS FROM AFFECTING FRIENDLY FORCES **ACT**
- IF PREVENTION FAILS, **DETECT** AND **AVOID** THREATS **SENSE AND ACT**
- **NEUTRALIZE** OR REDUCE EFFECTS THAT CANNOT BE PREVENTED OR AVOIDED **SHIELD**
- **CONSEQUENCE MANAGE** AFTER THE EVENT TO MITIGATE SEVERITY **SUSTAIN**

Success in Shield does not guarantee a win but failure in Shield can deliver a loss

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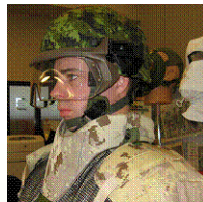
Shield & Survivability vs Sense



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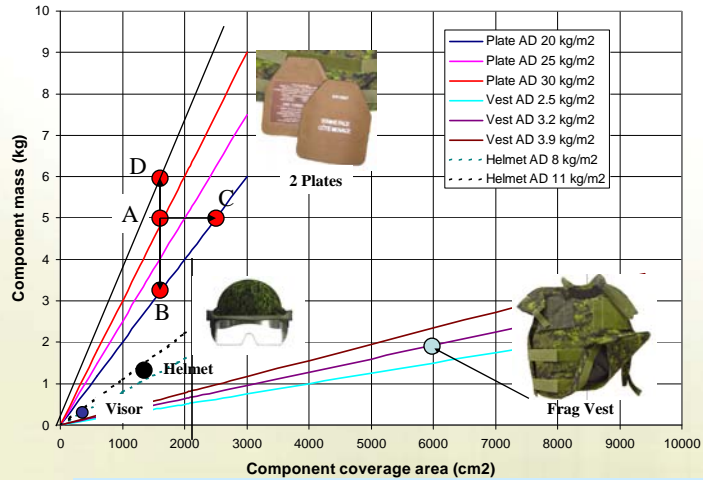
PPE Sub-Systems

- **Headborne**
 - Head (Helmet)
 - Ears (Headset, Earplugs)
 - Face (Visor/Goggles)
 - Eye (Ballistic eyewear)
 - Neck
 - Throat (protector, collar)
 - Nape (guard, collar)
 - Mandible (guard)
- **Torso**
 - Upper (FPV, BRP)
 - Lower (FPV)
 - Sides (FPV, plates?)
- **Extremities**
 - Groin
 - Upper arms (Brassard)
 - Upper legs
 - Feet (Boots)



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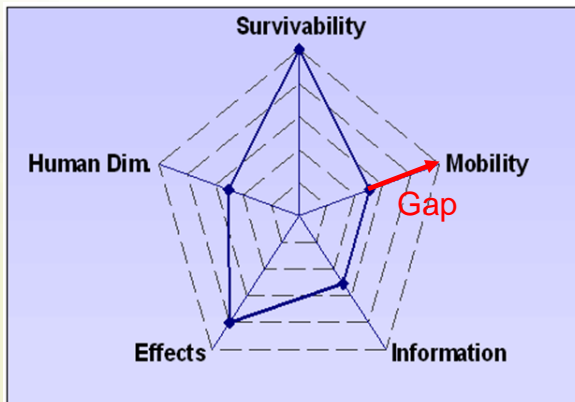
PPE Weight vs Coverage & Protection



Protection options:

- A: current weight, coverage & current material
- B: lower weight & same coverage: lower level (same mat.) or same level (new mat.)
- C: same weight & higher coverage: lower level (same mat.) or higher level (new mat.)
- D: higher weight & same coverage: higher level (same material)

Future PPE Trade-off Space



- Threat based?
- Capability based?
- Injury based?
- Incapacitation based?
- Effects based?

Main Ballistic Threats (NATO)

Threat Type	Category	Description
Ballistic		
Fragments	<i>HE Fragments, Natural fragmentation</i>	The threat of a soldier being struck by direct or secondary material propelled by explosive weapons or projectiles (e.g. 'natural' fragmentation from artillery fragments, fragmentation mines, ...).
	<i>HE Fragments, Anti – personnel fragmentation</i>	The threat of a soldier being struck by direct or secondary material propelled by explosive weapons or projectiles, optimised against personal targets, (e.g. pre-fragmentation)
Bullets	<i>Direct Fire personal weapon</i>	The threat of a soldier being struck by a solid projectile (e.g. ball ammunition), fired from an individual served weapon, such as 5.56 & 7.62 mm etc.
	<i>Direct Fire platform weapon system</i>	The threat of a soldier being struck by a solid projectile (e.g. ball ammunition), fired from an individual or crew served weapon, such as 12.5 mm, .50 etc.
	<i>Sniper</i>	The threat of a soldier being struck by a solid projectile (e.g. ball ammunition), fired from an individual served weapon.

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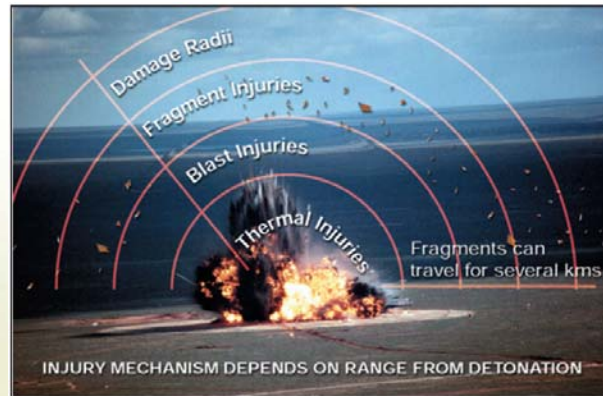
Other Ballistic Threats

Threat Type	Category	Description
Ballistic		
Handheld weapons	<i>Direct Fire handheld weapons</i>	The threat of a soldier being struck by a solid projectile (e.g. ball ammunition), fired from an individual served weapon, military and civil, such as 9 mm pistol.
	<i>Flechettes</i>	Flechette threat, for instance generated by artillery sub calibre, 25 mm weapons, typical mines etc..
Secondary Fragments	<i>Spall Fragments</i>	The threat of a soldier being struck by secondary material propelled by explosive weapons or projectiles (e.g. behind armour debris, spall etc. ...).
	<i>Shape charge jet, including fragmentation</i>	The threat of a soldier being struck by a shape charge jet including fragmentation, originating from AT weapon or artillery sub munitions.

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Fragmentation/Blast Threats

- AP Mine
- Grenade
- Mortar and Artillery Shells
- RPG
- Enhanced Blast (future threat?)



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Characteristics of Fragmentation Threats

- **Natural fragmenting munitions**
 - Large number of fragments (7000-14000) of all sizes (0.5 to 500 gr)
 - Initial velocity from 1000 to 1800 m/s
 - L/D or shape factor variable typically 0.5 to 1.1
- **Pre-formed fragmenting munitions**
 - Spheres:
 - Mines: 7/32 in sphere (0.7 grams)
 - Grenades: 2.5-3.0 mm sphere (0.12 grams)
 - Cubes, steel or tungsten
- **Controlled fragmentation**
 - Made of steel typically, 30 Rc hardness

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Blast Threat

Threat Type	Category	Description
Blast		
Conventional Blast	<i>Blast – Conventional</i>	The threat to a soldier due to the brief and rapid movement of air, vapour and fluid away from a centre of outward pressure (e.g. explosion, fuel detonation,)
	<i>Sensory – Sonic</i>	The threat to a soldier when exposed to strong and/or repetitive air pressure waves. These include the sound from close explosions as well as impulse noise caused by operation of infantry weapons, particularly repetitive noise from automatic weapons (e.g. heavy machine guns).
Mine Blast	<i>AT mine</i>	The threat to a soldier when exposed to a blast wave, originating from a detonating AT-mine under a vehicle.

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Fragmentation Threats

Close in Fragmentation vs Blast



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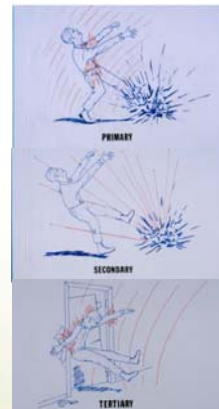
IED Threat Implications (Improved Explosive Devices)

- **Closer proximity from detonation**
 - Synergy from blast and fragments
 - Higher fragment density & velocity
 - At short range: blast arrives before fragments thus the need for live field tests
 - Fragment impact can be simultaneous
 - Negative incident angle
- **Larger fragment variability**
 - Size, shape, material
 - Higher fragment masses

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Blast Injuries vs Stand-off Distance

<i>Location</i>	<i>Close Proximity</i>	⇔	⇔	⇔	⇔	⇔	⇔	<i>Distant</i>
Total body disruption								
Burns and inhalation injuries								
Toxic Inhalations								
Traumatic Amputations								
PBI of the lung and bowel								
Tertiary blast injuries								
PBI of the ear								
Secondary Blast Injuries								



1. **Primary:** Direct exposure to overpressurization wave
2. **Secondary:** Impact from blast energized debris – penetrating and non-penetrating
3. **Tertiary:** Displacement of the person by the blast and impact
4. **Quaternary:** Burns/Inhalation of gases

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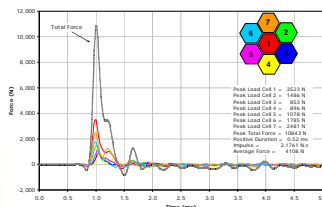
Traumatic Brain Injuries (TBI)

- **Ongoing debate over the link between blast overpressure and mild TBI:**
 - There is no conclusive evidence that a direct effect of shock/overpressure (if it exists) is the dominant injury mechanism which is leading to a rise in mTBI.
 - 'Pure' blast event is only a fraction of the exposure to potential mTBI inducing loading.
 - Exception is repeated exposure to low level shock/overpressures from large calibre and/or automatic weapons fire.
 - Typically the detonation of an IED is accompanied by large accelerations in an environment rich in 'bump' hazards.

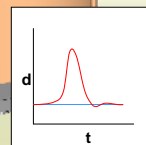
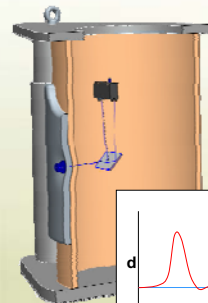
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Novel PPE Assessment Tools

BABT Headform



Thoracic Membrane



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Test Fragments and Bullets

- Fragments:
 - 1, 16, 96 gr sphere
 - 17 gr FSP
 - 2, 4, 16, 64 gr RCC



- Bullets:
 - Handgun
 - 9 mm FMJ **Not relevant?**
 - Rifle
 - 5.56x45 SS109 Stanag level 1
 - 7.62x51 M80 Stanag level 1
 - 7.62x51 M993 Stanag level 3

Not relevant as a threat in theatre (currently) but used to assess BAPT performance of armour

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Survivability and PPE Future Vision

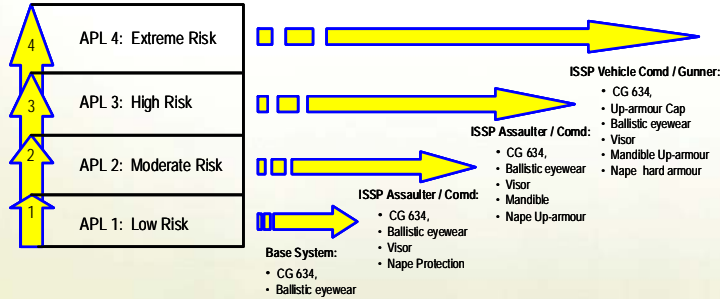
- **Prioritization**
 - Prevent serious injuries (survivability)
 - Prevent severe injuries (incapacitation, evac, clinical impact)
 - Prevent mild injuries (quality of life (mTBI), clinical impact)
 - Will this be valid in the future?
- **5 years goal?**
 - Enhanced protection/coverage at same weight
- **10 years goal?**
 - Enhanced protection/coverage at lower weight
- **15 years goal?**
 - Full coverage and greater protection at lower weight? (no bulk, no weight, no stiffness, low cost!!)

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Example of Modular Protection Framework SIHS Head Armour Protection Levels

Armour Protection Levels
(similar to MOPP)

An example of how modular protection would
be applied in an operational context.



Base System: APL 2 Variant: APL 2 Variant: APL 3 Variant: APL 3 Variant: APL 4 Variant:

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Future PPE Drivers & Constraints

- **Integrated vs modular or scaleable**
 - Role can change as mission progresses (could be in 30 hrs, 30 min or 30 sec)
- **Crew vs dismounted**
 - Integration with vehicle systems
 - Rapid on/off
 - Snag hazards
 - No longer discrete roles
 - Soldier may mount, fight mounted, then dismount and fight/patrol
- **Integrated multi-threat protection**
 - Blast, frag, ballistic, impact
- **Integration with C4I and load carriage**
 - Is armour a load to be carried or the load carrier?
 - Thoracic armour is not optimal form for carrying large loads
- **Human factors (form, fit, function, weight and bulk)**
 - Interfaces (neck..)
 - Coverage and Thermal Load
 - Anthropometry
- **Compatibility with legacy equipment**
 - CBRN, gloves, sights, vehicles, NVGs
- **Integration of other features to increase survivability (e.g. crew extraction)**



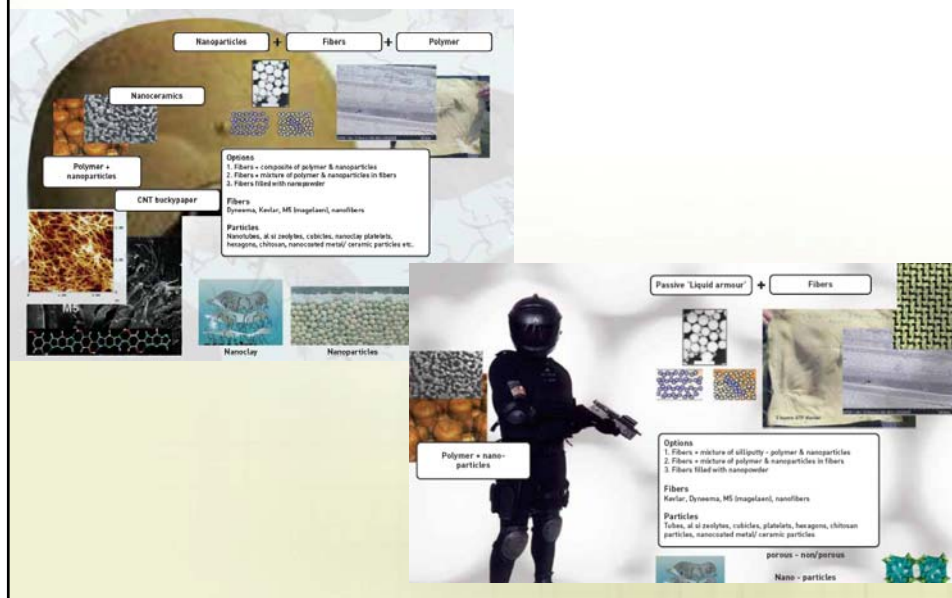
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PPE and Survivability Challenges

- Understand well the various threats and related injury mechanisms
- Implement suitable testing protocols to properly capture the injury mechanisms
 - Head and torso blunt trauma
 - Head neurotrauma
 - Primary/tertiary blast injuries
- Incorporate novel material systems (e.g. nano-technologies)
 - Requires thorough understanding of long term properties
 - Multifunction materials
- Exploit novel concepts for role specific coverage (e.g. modular helmet)
- Trade-offs between coverage, weight, protection
 - Requirement is neutral weight design of new concepts (including additional capabilities)

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Nanotechnology Potential



KEY CRITERIA FOR PPE SUCCESS: SOLDIER ACCEPTANCE



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QUESTIONS ?



For more information, please consult:
<http://soldiersystems-systemesdusoldat.collaboration.gc.ca>