Soldier Lethality and Wound Ballistics
from a Swedish Perspective

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Agenda

- Wound ballistics.
- Small arms lethality.
Two ways to incapacitate

1. Hit to the central nervous system.
   - Immediate incapacitation regardless of caliber or type of projectile!

2. Loss of blood pressure by massive bleeding.
   - This happens if the projectile can create a large wound.
   - The projectile has to have:
     ▸ High kinetic energy (velocity and mass).
     ▸ Large braking area (large caliber, expanding or fragmenting projectile).
     ▸ Large penetration.
   - Incapacitation can take time!
Wound ballistics

- Energy dump in the target is an indication that "work" has been done.
- This "work" means that a temporary and permanent cavity has been created.
- The temporary cavity is caused by the hydrodynamic shock wave.
- The permanent cavity represents the destroyed tissue.
Swedish wound ballistic research

- Large study in the 1970’s concluded that human and pig muscles were similar.
- Wound ballistic research was done on anesthetized pigs.
- These are still used for medical training in Sweden.
Test medias

- Wood
- Water soaked paper
- Plasticine
- Clay
- Water
- Gelatin
- Soap
Swedish ballistic soap

- In Sweden we use ballistic soap as a test media.
- It shows the temporary cavity.
- Swedish research has concluded that 140mm of ballistic soap corresponds to the amount of human tissue destroyed if the target is hit from the frontal arc.
Soap block ballistic test setup

The impact and exit velocities are recorded, and the energy dump is calculated.
Energy dump in 140mm soap at 100m

Typical values:

- 5.56 NATO: 180J
- 7.62 NATO: 250J

In tissue this would be the temporary cavity. The diameter corresponds to the dumped energy at that point.
Small arms lethality

- Shot placement
- Distance
- Ammunition
- Target
- Weapon
- Caliber

Lethality
Shot placement

The single most important factor!

"80%"
Movies and computer games...

- By watching movies and playing computer games some soldiers believe that a hit anywhere will bring the enemy down...
- ...and that he will stay down!
Target

- Size.
- Motivation.
- Protection (body armor).
Ranges are short!

Legend
Desert: Arab Israeli War
Rural: WW II, Korea
Jungle: WW II, Vietnam
Urban: Street & Bldg Survey

Statistics from JSSAP, USA

Information from the NATO Infantry Weaponry Master Plan 2004
Engagements conducted with small arms occurred in the 20-30m range.

Shots over 100m were rare.

The maximum range was less than 300m.

Information from the NATO Infantry Weaponry Master Plan 2004
Weapon

- Barrel length (muzzle velocity).
- Rifling twist.
Future individual weapons

- Evolution – no revolution!
- Caliber 5.56 NATO.
- Mil-Std-1913 rail.
- Red-dot sight.
- Short barrel.

Information from the NATO Infantry Weaponry Master Plan 2004
Inner ballistics

50% of $V_0$ within 80mm (3’’)!
Caliber

- Energy.
- Capability.

<table>
<thead>
<tr>
<th>Caliber</th>
<th>E₀ (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9x19mm NATO</td>
<td>500J</td>
</tr>
<tr>
<td>5.56x45mm NATO</td>
<td>1700J</td>
</tr>
<tr>
<td>7.62x51mm NATO</td>
<td>3300J</td>
</tr>
<tr>
<td>12.7x99mm NATO</td>
<td>17 000J</td>
</tr>
</tbody>
</table>
Ammunition

- **Projectile:**
  - **Type:**
    - FMJ
    - Tracer
    - AP
  - **Mass**
  - **Velocity**
- **Stability.**
- **Fragmentation.**
5.56 NATO (FN SS109/US M855)

Basic data:
- $V_0 = 930$ m/s
- $m_P = 4.0$ g
- $S = 1/7$” (1/178mm)
Projectile yaw angle

- Projectile in flight = Spinning top!
- Three phases:
  1. Large initial yaw angle = precession.
  2. Stable.
  3. Tilt.

\( \alpha = \text{Precession} \)
Yaw characteristics
5.56 NATO

Total angle of attack; maximum yaw amplitude = 10.4 degrees
If the velocity is high enough the projectile can fragment.

This creates fragments that work like secondary projectiles, which creates a larger wound channel.

For the 5.56 NATO projectile the threshold velocity for fragmentation is approx. 760 m/s (2500 fps).
Swedish error budget study

- Shooting errors ("SARA").
- Weapon and ammunition.
- Range estimation.
- Target lead.
- Shooting uphill or downhill.
- Temperature difference.
- Drift due to rotation.
- Wind.

S=Position
A=Breathing
R=Aiming
A=Trigger pull
Results: two scenarios

- Short range (< 100m):
  - Shooting errors (“SARA”).
  - Target lead.

- Long range (> 100m):
  - Shooting errors (“SARA”).
  - Target lead.
  - Range.
  - Wind.

S=Position
A=Breathing
R=Aiming
A=Trigger pull
How to improve shot placement

- Proper basic shooting training ("SARA").
- Realistic combat training!
- Good sights.
- Smaller targets.

S=Position
A=Breathing
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SWE Aimpoint CS Red-Dot Sight
New Swedish pop-up target

Original target

Modified target

Sheet metal (w=120mm)

Cardboard
Summary

- Shot placement is the key to lethality!
- Proper shot placement is reached by basic shooting training, and realistic combat training!
Questions?

Visit our web site at www.fmv.se