Ballistics

Ballistics

Everything that happens to the projectile from the time the primer is struck by the firing pin until the projectile comes to a complete stop.

There are three ballistic phases:

1. **Internal**
2. **External**
3. **Terminal**

Internal ballistics –

The study of the propulsion of a projectile. Internal ballistics begin from the time the firing pin strikes the primer to the time the bullet leaves the muzzle. Once the primer is struck the priming charge ignites the propellant. The expanding gases caused by the burning propellant create pressures which push the bullet down the barrel. The bullet engages the lands and grooves (rifling) imparting a spin on the bullet that facilitates stabilization of the projectile during flight. Internal ballistics ends at shot exit, where the bullet leaves the muzzle.

Ballistics

EXTERNAL BALLISTICS

External ballistics is the study of the physical actions and effects of gravity, drag, and wind along the projectile's flight to the target. It includes only those general physical actions that cause the greatest change to the flight of a projectile.

External ballistics begins at shot exit and continues through the moment the projectile
strikes the target.

EXTERNAL BALLISTICS FACTS

A. Gravity and air resistance have a constant and continuous effect on a bullet passing through the air

B. This constant effect causes the flight (trajectory) of the bullet to be a definitive and uniform arc.

C. A common cylindrical bullet has no loft capabilities. It never rises under its own power.

D. The sole purpose of the spin that is imparted upon a bullet is to keep the projectile from tumbling end over end.

E. A bullet fired from a true horizontal barrel begins to slow down and fall towards the earth immediately upon leaving the muzzle of the weapon.

Ballistics

A bullet flying through the air(WITHOUT WIND) is acted upon primarily by two forces, which change the direction and velocity of its motion.

These two forces are:

1. Gravity

   -Causes the bullet to fall towards the earth

2. Air Resistance

   -Causes the bullet to slow down

   -Causes the bullet to fly erratically and tumble

Ballistics

We as shooters counter these forces on the bullet by:

A. ***Increasing the angle of departure (elevating the muzzle)*** to counter the effects of gravity

B. ***Imparting spin*** and ***high velocities*** on the bullet counter air resistance and allow the bullet to fly in an nose forward manner at far distances.

These two basic concepts will help you to visualize how a bullet is sent through the air when leaving a rifle barrel.

A. The flight of a football.

B. A child's top.

TERMINAL BALLISTICS

Terminal ballistics is the science of the actions of a projectile from the time it strikes an <u>object until it comes to rest</u> (called terminal rest). This includes the terminal effects that take place against the target.

<u>Kinetic Energy (EK)</u> – a unit of measurement of the delivered force of a projectile. Kinetic energy is the delivered energy that a projectile possesses due to its mass and velocity at the time of impact. Kinetic energy is directly related to the penetration capability of a projectile against the target.

<u>Penetration</u> – the ability or act of a projectile to enter a target's mass based on its delivered kinetic energy. When a projectile strikes a target, the level of penetration into the target is termed the impact depth. The impact depth is the distance from the point of impact to the moment the projectile stops at its terminal resting place. Ultimately, the projectile stops when it has transferred its momentum to an equal mass of the medium (or arresting medium).

STRUCTURE PENETRATION

The following common barriers in built-up areas can prevent penetration by a 5.56-mm round fired at less than 50 meters (M855) including:

- Single row sandbags.
- A 2-inch thick concrete wall (not reinforced with rebar or similar item).
- A 55-gallon drum filled with water or sand.
- A metal ammunition can filled with sand.
- A cinder block filled with sand (the block may shatter).
- A plate glass windowpane at a 45-degree angle (glass fragments will be thrown behind the glass).
- A brick veneer.

Ballistics

Permanent Wound Cavity

The permanent cavity refers specifically to the physical hole left in the tissues of soft targets by the pass-through of a projectile. It is the total volume of tissue crushed or destroyed along the path of the projectile within the soft target.

Depending on the soft tissue composition and density, the tissues are either elastic or rigid. Elastic organs stretch when penetrated, leaving a smaller wound cavity. Organs that contain dense tissue, water, or blood are rigid, and can shatter from the force of the projectile. When a rigid organ shatters from a penetrating bullet, it causes massive blood loss within a larger permanent wound cavity. Although typically fatal, striking these organs may not immediately incapacitate the target.

Ballistics

Temporary Wound Cavity

The temporary wound cavity is an area that surrounds the permanent wound cavity. It is created by soft, elastic tissues as the projectile passes through the tissue at greater than 2000 feet per second. The tissue around the permanent cavity is propelled outward (stretched) in an almost explosive manner from the path of the bullet. This forms a temporary recess or cavity 10 to 12 times the bullet's diameter.

Tissue such as muscle, some organs, and blood vessels are very elastic and can be stretched by the temporary cavity with little or no damage and have a tendency to absorb the projectile's energy. The temporary cavity created will slowly reduce in size over time, although typically not returning completely to the original position or location.

TEMPORARY CAVITATION

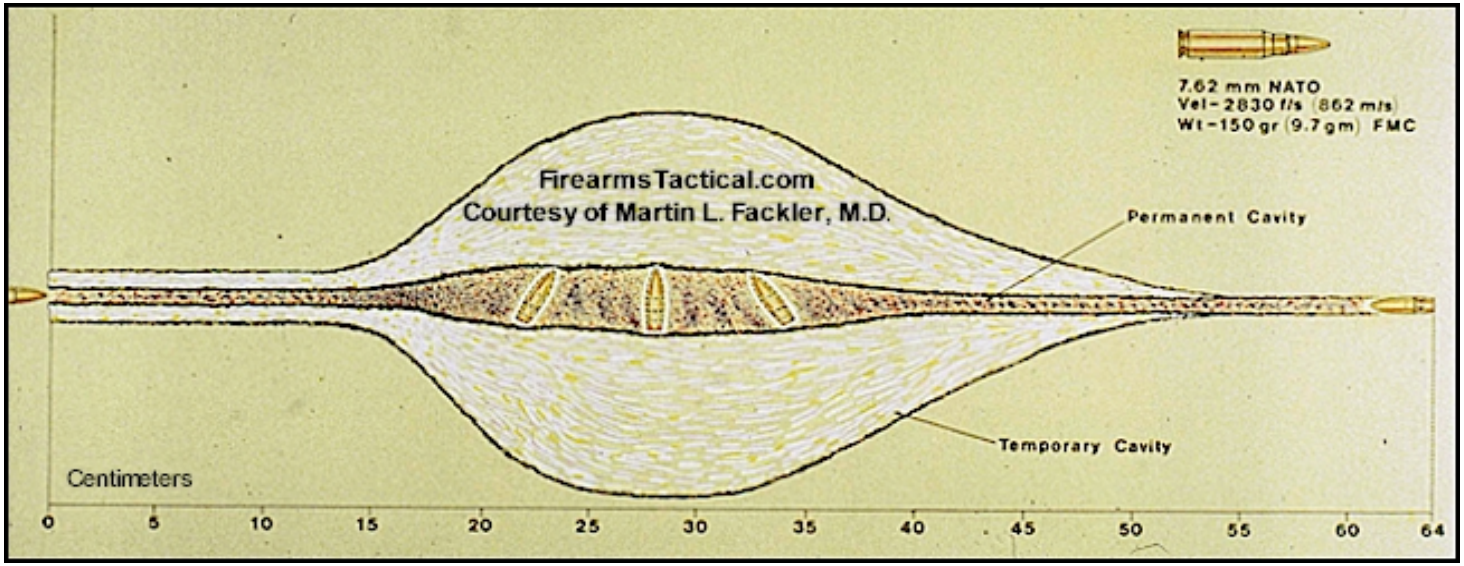
Temporary cavitation can be a significant mechanism of wounding, especially with rifle bullets, but is extremely variable and erratic.

Elastic tissues are good energy absorbers and are highly resistant to temporary cavity stretch injuries: Muscle, Bowels, Skin, empty hollow organs, and Blood Vessels.

Inelastic tissues are highly susceptible to severe splitting, tearing, or rupture due to temporary cavity stretch injuries: Brain, Liver, Kidney, Spleen, Pancreas, and completely full fluid or gas filled hollow organs.

BULLET PERFORMANCE

At all ranges, upon striking soft tissue, M118SB and M80 Ball yaw 180 degrees and then after reaching the base-forward position, continue the rest of its path with little or no yaw. This is because their rotation is insufficient to maintain point forward travel through tissue which is denser than air.



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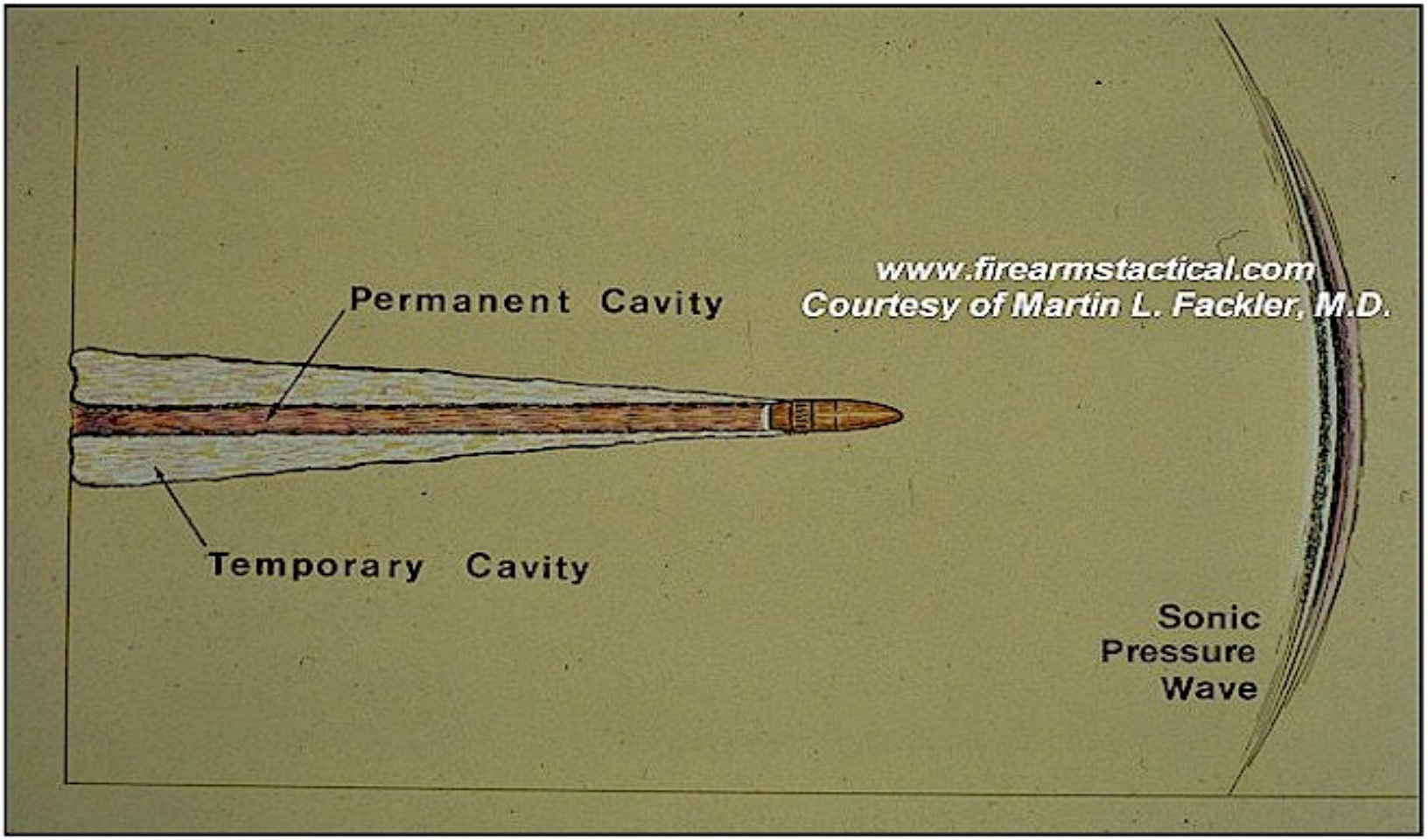
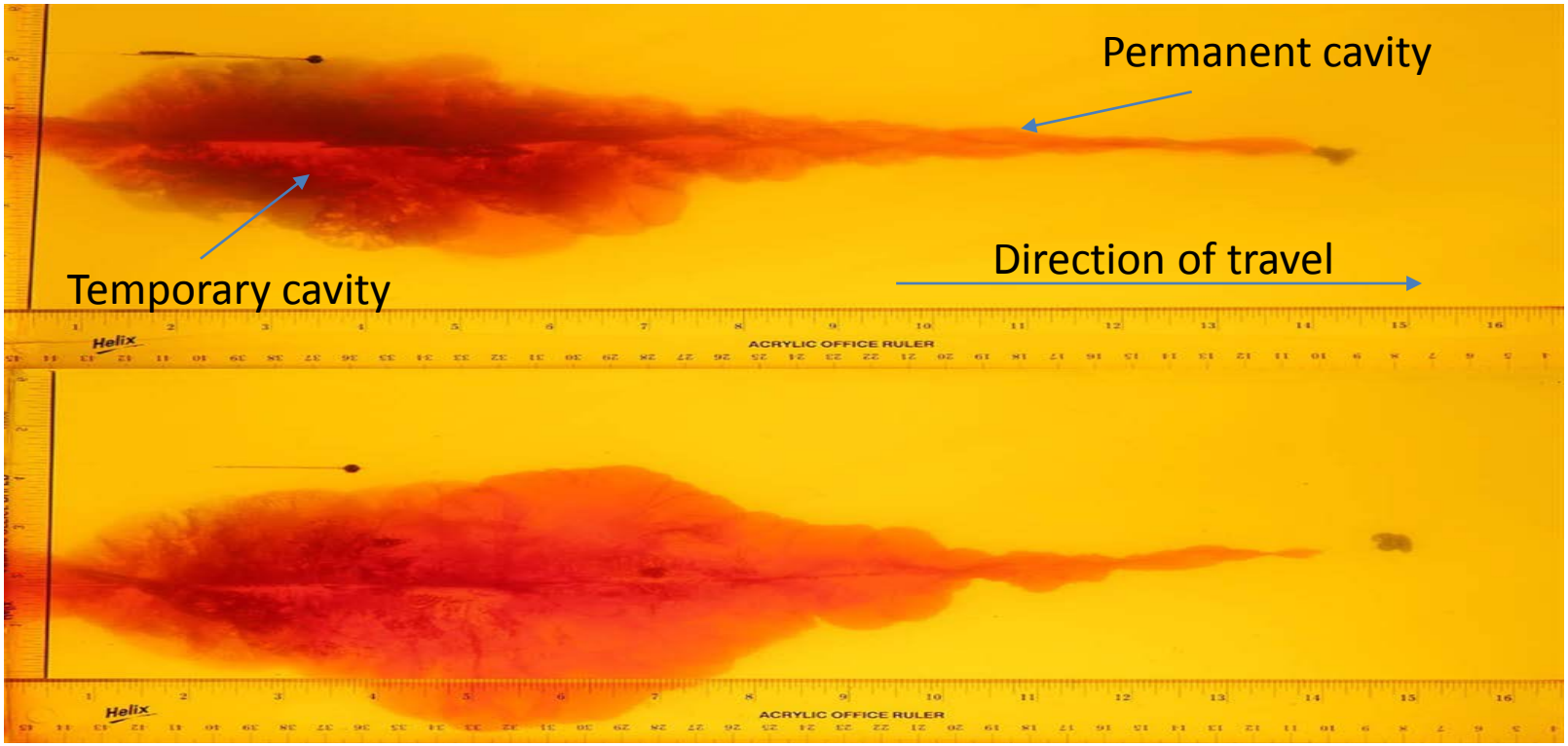


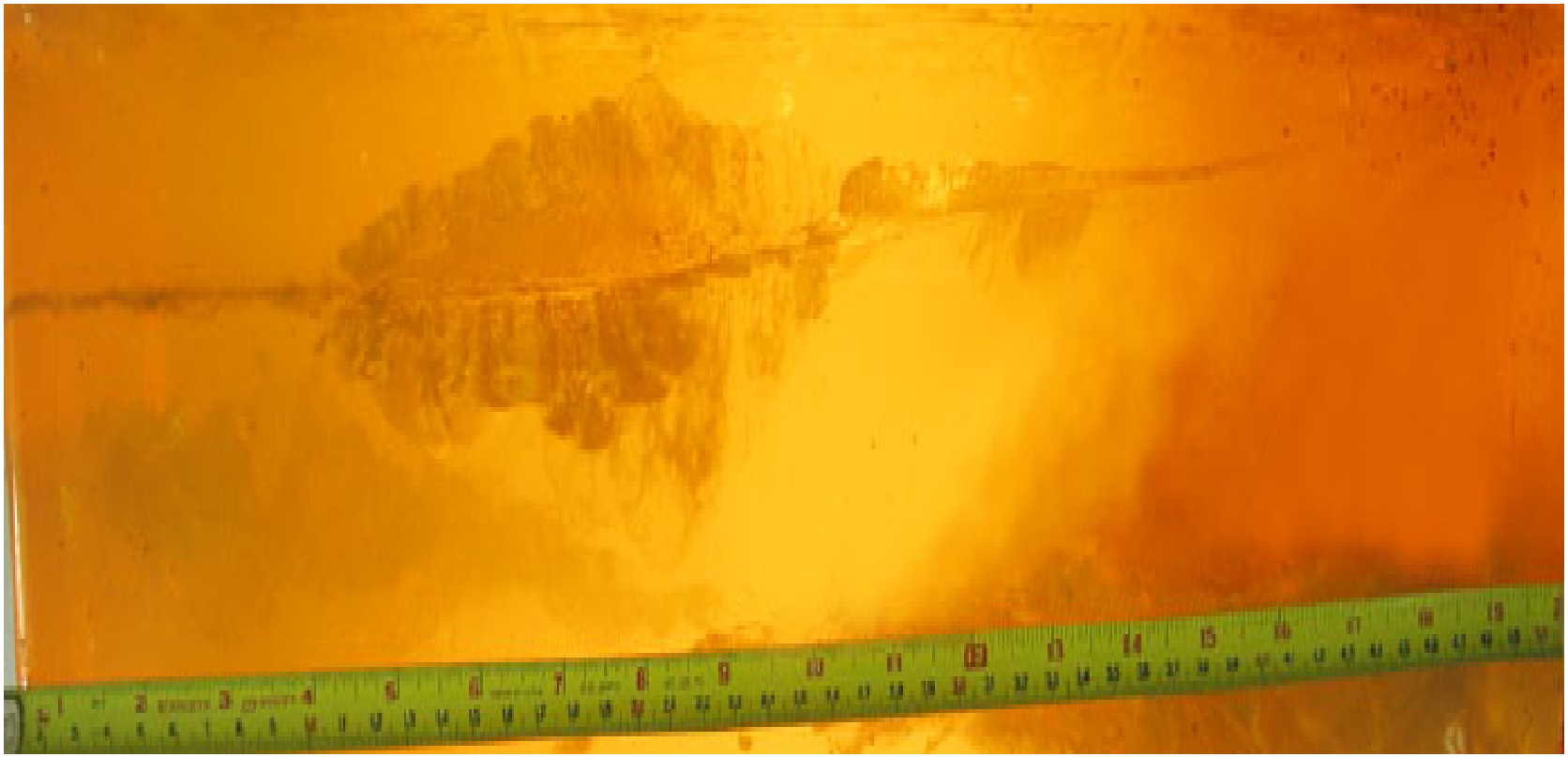
Ballistics

Temporary and permanent wound cavity:



BULLET PERFORMANCE

M118LR shot into ballistic gelatin at 400m.



RIFLE BULLET FRAGMENTATION

Rifle bullet fragmentation in tissue can greatly increase the tissue disruption in two ways:

- Direct crush from the fragments
- Effects of stretch on tissue newly cut by fragments.

Fragmentation occurs in high velocity projectile wounds with an impact velocity greater than 2000 fps inflicted by soft point or hollow point bullets. (Approx. 300m for M24 firing M118LR)

Fragmentation:

Terminal Ballistic Terms:

Kinetic energy (EK) – the delivered mass at a given velocity. Higher delivered kinetic energy produces greater penetration and tissue damage.

Yaw – any yaw at the point of impact increases the projectiles surface area that strikes the target, decreasing kinetic energy, but increasing the penetration and cavity size.

Deformation – the physical changes of the projectile's original shape and design due to the impact of the target. This increases the projectile's surface area and the size of the cavity created after penetration.

Fragmentation – the fracturing of a projectile into multiple pieces or sub-projectiles. The multiple paths of the fragmented sub-projectiles are unpredictable in size, velocity, and direction. The bullet jacket, and for some types of projectiles, the lead core, fracture creating small, jagged, sharp edged pieces that are propelled outward with the temporary cavity. Fragments can sever tissue, causing large, seemingly explosive-type. Bone fragments caused by the bullet's strike can have the same effect.

Tumbling – the inadvertent end-over-end rotation of the projectile. As a projectile tumbles as it strikes the target, the bullet travels through the tissues with a larger diameter. This causes a more severe permanent cavity as it passes through the soft tissue. A tumbling projectile can change direction erratically within the body due to its velocity and tendency to strike dense material with a larger surface area.

SOFT TISSUE PENETRATION

A gunshot wound, or ballistic trauma, is a form of physical damage sustained from the entry of a projectile. The degree of tissue disruption caused by a projectile is related to the size of the cavities created by the projectile as it passes through the target's tissue. When striking a personnel target, there are two types of cavities created by the projectile; permanent and temporary wound cavities.

Lethal Zones

The Soldier's primary point of aim at any target by default is center of visible mass. This allows for a tolerance that includes the greatest margin of error with the highest probability of a first round hit. The combat conditions may require more precise fires at partially exposed targets or targets that require immediate incapacitation.

Ideally, the point of aim is anywhere within a primary switch area. This point will maximize the possibility of striking major organs and vessels, rendering a clean, oneshot kill (see figure B-4.)

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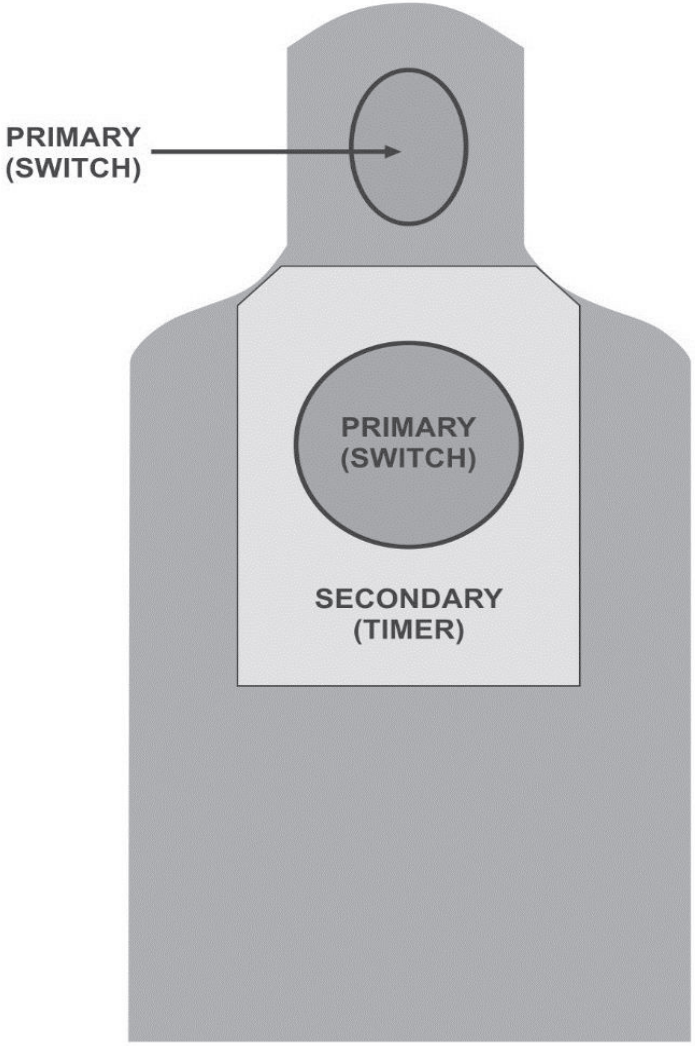


Circuitry Shots (Switches)

Circuitry shots, or “switches,” are strikes to a target that deliver its immediate incapacitation. Immediate incapacitation is the sudden physical or mental inability to initiate or complete any physical task. To accomplish this, the central nervous system must be destroyed by hitting the brain or spinal column. All bodily functions and voluntary actions cease when the brain is destroyed and if the spinal column is broken, all functions cease below the break.

Hydraulic Shots (Timer)

Hydraulic shots, or “timers,” are impacts on a target where immediate incapacitation is not guaranteed. These types of ballistic trauma are termed “timers” as that after the strike of the bullet, the damage caused requires time for the threat to have sufficient blood loss to render it incapacitated. Hydraulic shots, although ultimately lethal, allow for the threat to function in a reduced capacity for a period of time.

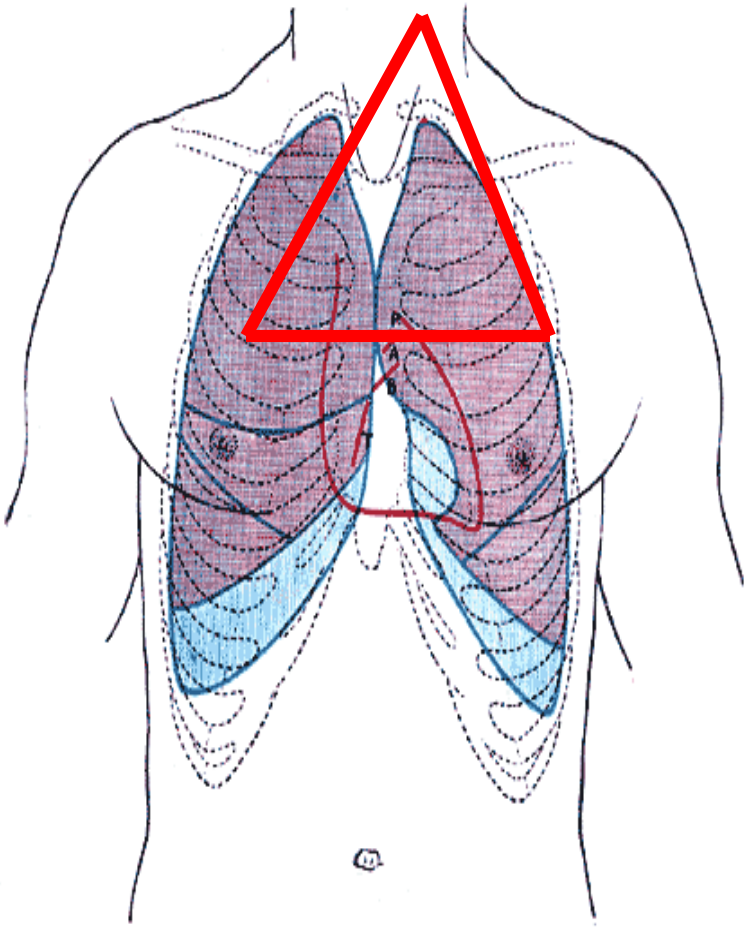
For hydraulic shots to eliminate the threat, they must cause a 40 percent loss of blood within the circulatory system. If the shots do not disrupt that flow at a rapid pace, the target will be able to continue its mission. Once two (2) liters of blood are lost, the target will transition into hypovolemic shock and become incapacitated.

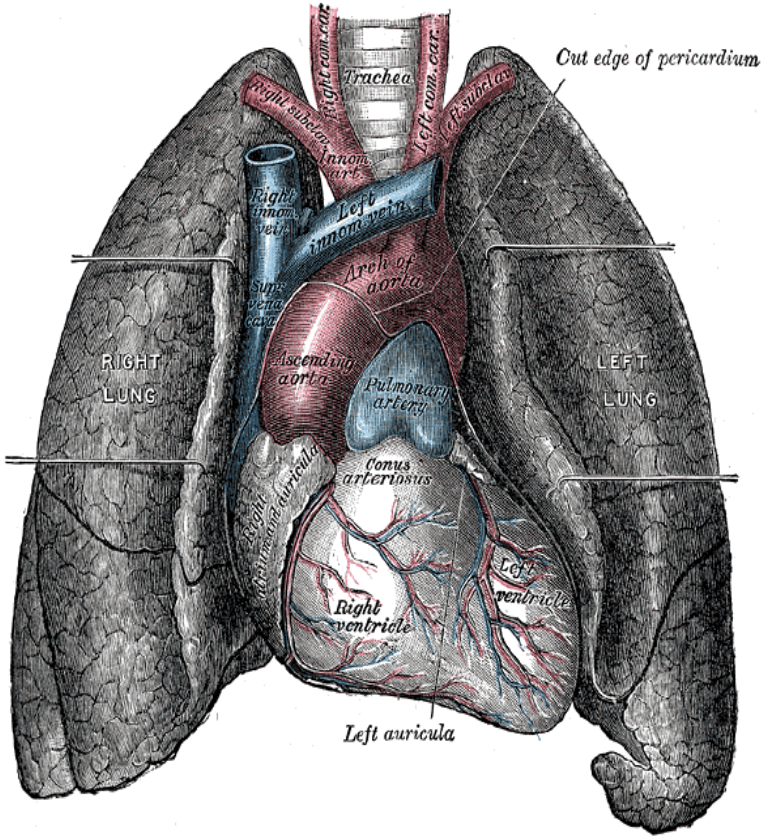
SHOT PLACEMENT

BODY SHOTS

- The POA is anywhere within the triangle formed by the base of the neck and the pectoral muscles.
- This point will maximize the possibility of striking major organs and vessels, rendering a clean, one-shot kill.

SHOT PLACEMENT
BODY SHOTS



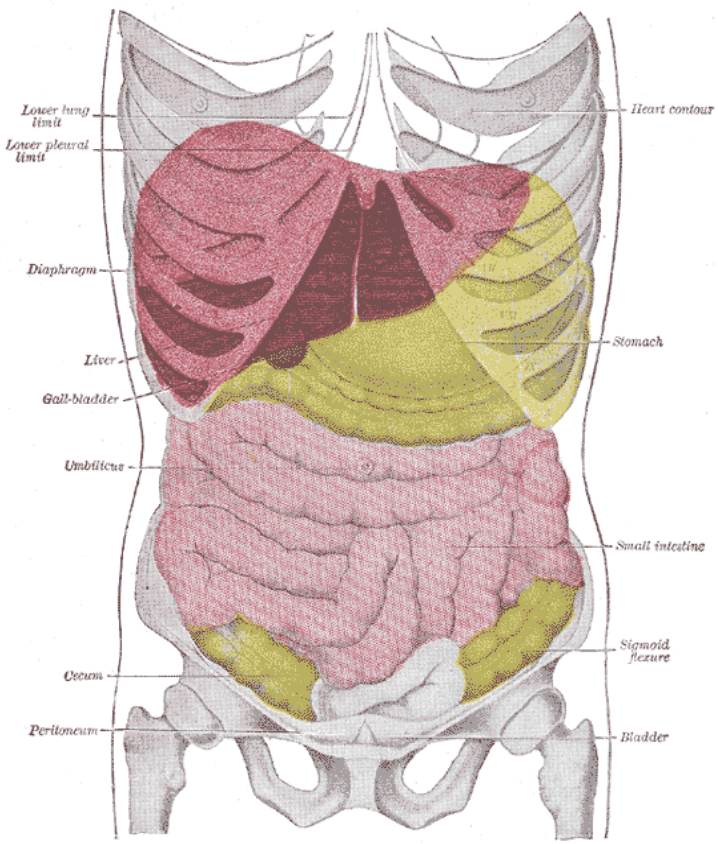


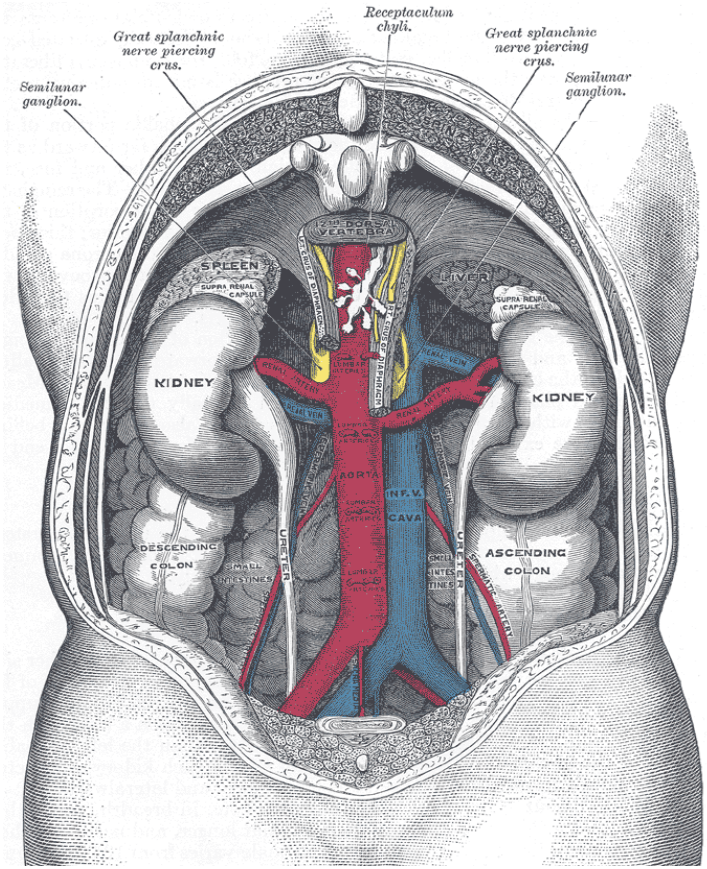
SHOT PLACEMENT

PELVIC AREA

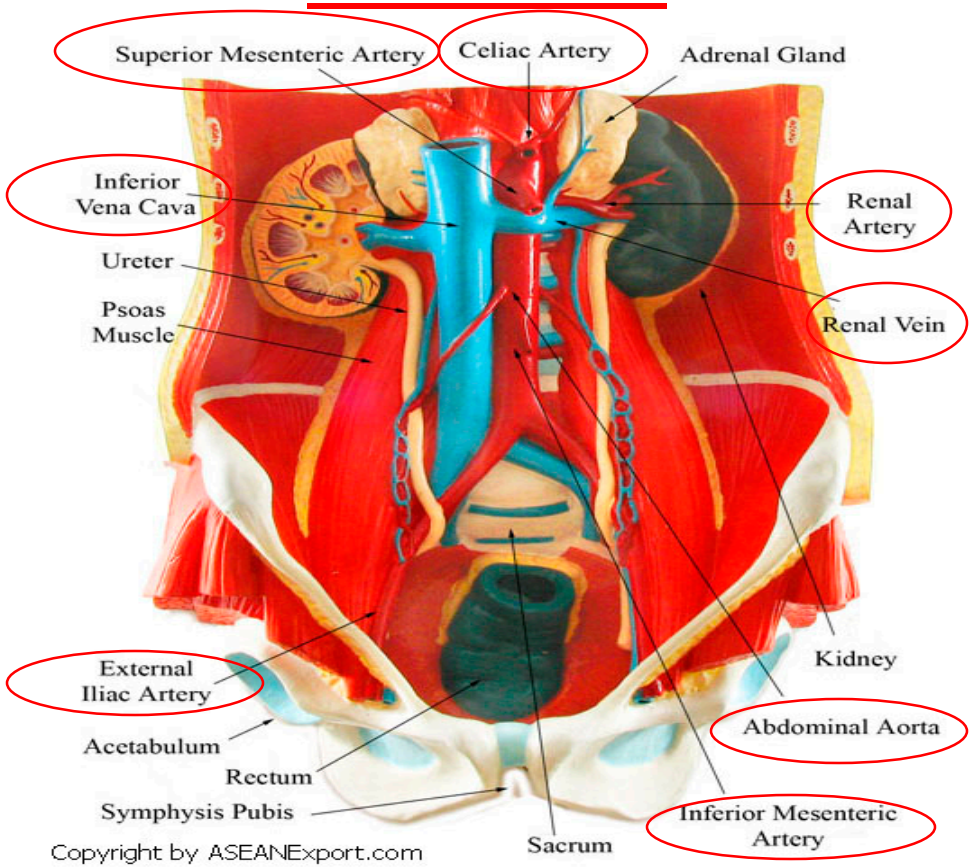
Used when the target is not completely visible or when the target is wearing body armor that prevents the shooter from engaging the primary zone.

SHOT PLACEMENT
PELVIC AREA





SHOT PLACEMENT
PELVIC AREA



This area is rich in large blood vessels and a shot here has a good possibility of hitting the lower spine.

AIMING POINTS

Primary Aiming point

Secondary Aiming Point

SHOT PLACEMENT

HEAD SHOTS

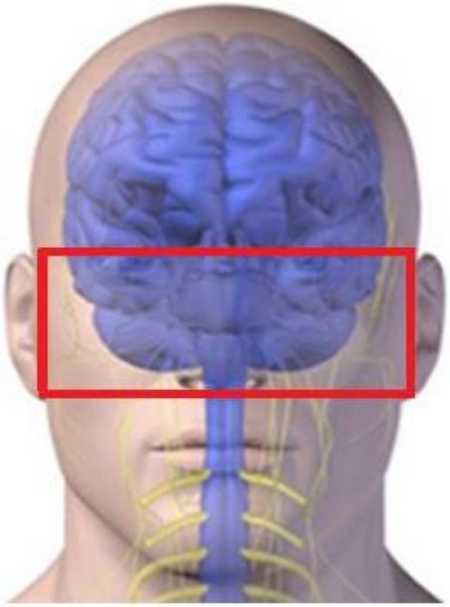
An alternate POA for closer than 300 meters is the head shot. This is very difficult to achieve because of its size and constant motion.
The advantage of the head shot is near instant incapacitation if the correct placement is achieved.
The head shot is well suited for hostage situations where closer ranges are the norm and instant incapacitation is required.

SHOT PLACEMENT

HEAD SHOTS

- With a well placed head shot, the target will not experience even reflexive motor action. His entire body will instantly experience what is called “flaccid paralysis.” The target’s muscles will suddenly relax and he will become incapable of any motion of any kind thereafter.

SHOT PLACEMENT
HEAD SHOTS



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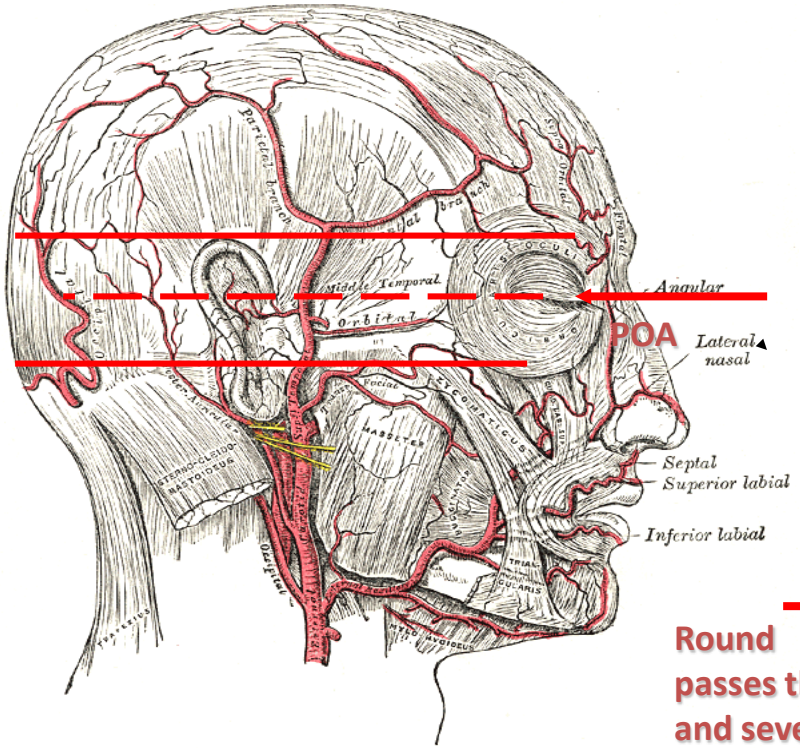
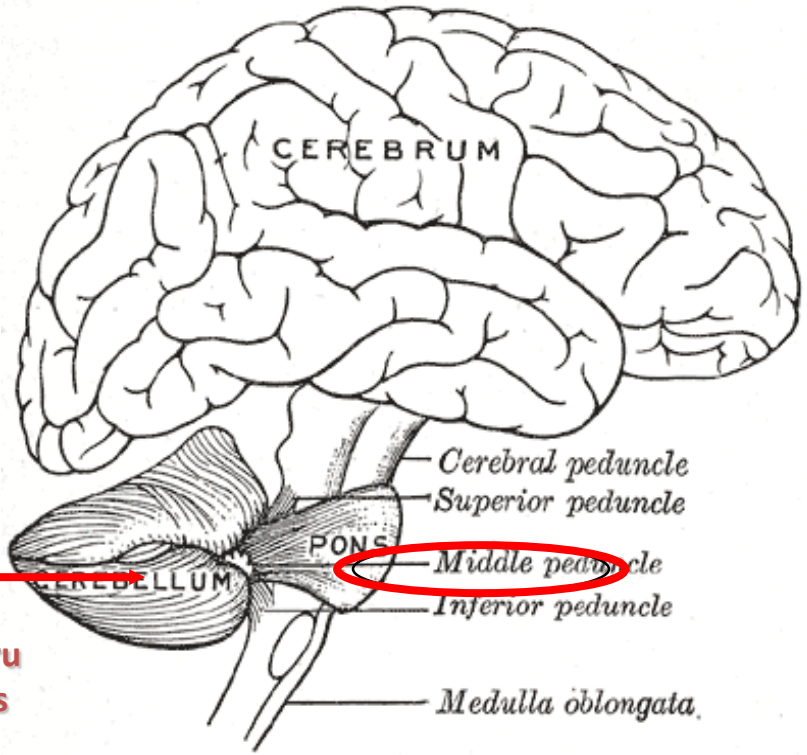
SHOT PLACEMENT
HEAD SHOTS





Round passes thru and severs

MECHANICS OF PROJECTILE WOUNDING

Defined: The study of the actions of a projectile from the time it strikes the target until it comes to rest.

Four components of projectile wounding:

1. Penetration
2. Permanent Cavity
3. Temporary Cavity
4. Fragmentation

THE HUMAN TARGET

PHYSIOLOGICAL FACTORS

- CNS Disruption (Circuitry Shot) – Caused by severing the spinal cord or destroying the medulla. Instantly neutralizes threat.

- Hypovolemic Shock (Hydraulic Shot) – Is caused by blood loss. This takes time! The human body contains 5 liters of blood. Loss of 2 liters is necessary. Even with a destroyed circulatory system, a threat can still function for 10-15 seconds.

PSYCHOLOGICAL FACTORS

Psychological stop:
- Awareness of injury
- Fear of death, blood, or pain
- Preconceived notions
- Desire to quit

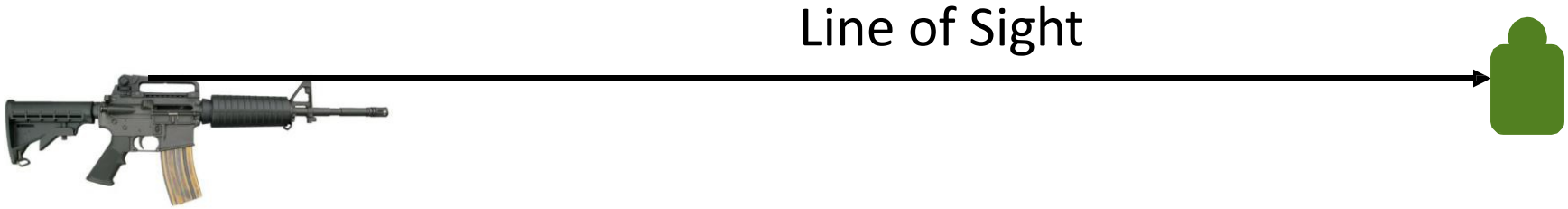
Adverse Psychological Factors
- Strong will
- Survival Instinct
- Emotion: Rage, Hate
- Adrenaline (pain suppression)
- Drugs: suppress pain and awareness of injury, eliminate concern

Parts of Trajectory

Line of Sight:

This is what the shooter sees behind the sights and can be illustrated by drawing a straight imaginary line from your eye through the rear and front sights out to the target

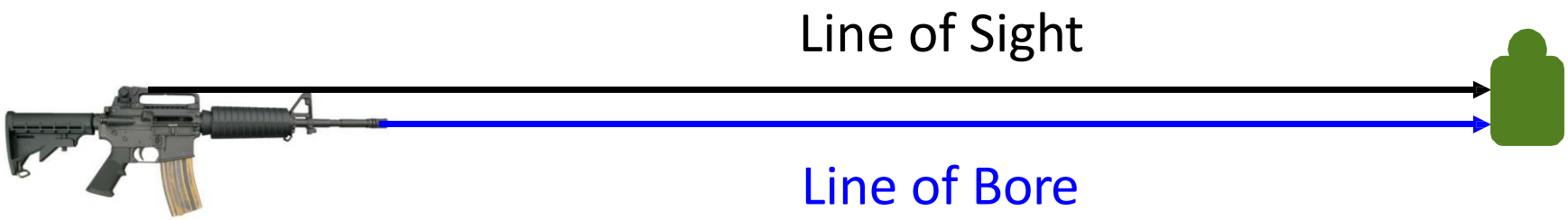
This is how you aim.



Trajectory

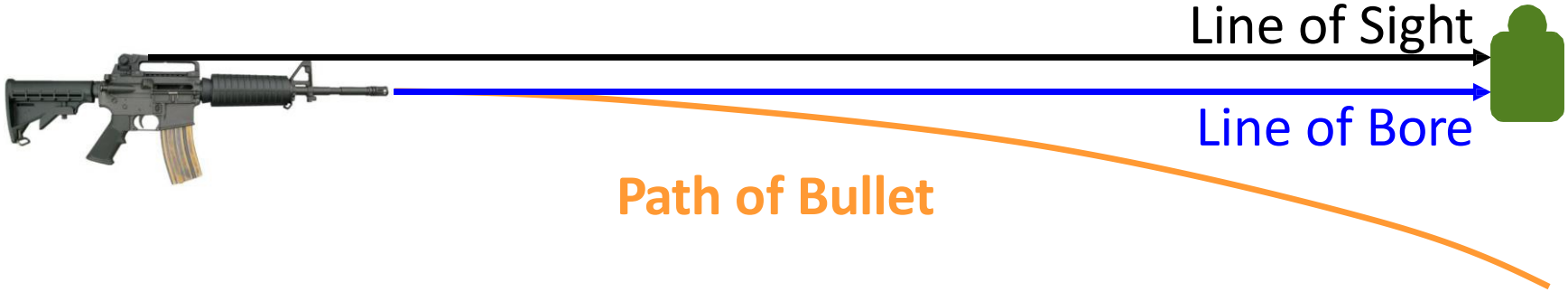
Line of Bore:

This is a straight imaginary line that is drawn from the muzzle of the rifle out to the target



Trajectory

Trajectory is the path that the bullet will take when it is fired from the rifle



Parts of Trajectory

3 Branches of Trajectory:

1. **Ascending (Rising)**
2. **Maximum Ordinate (Summit)**
3. **Descending (Falling)**

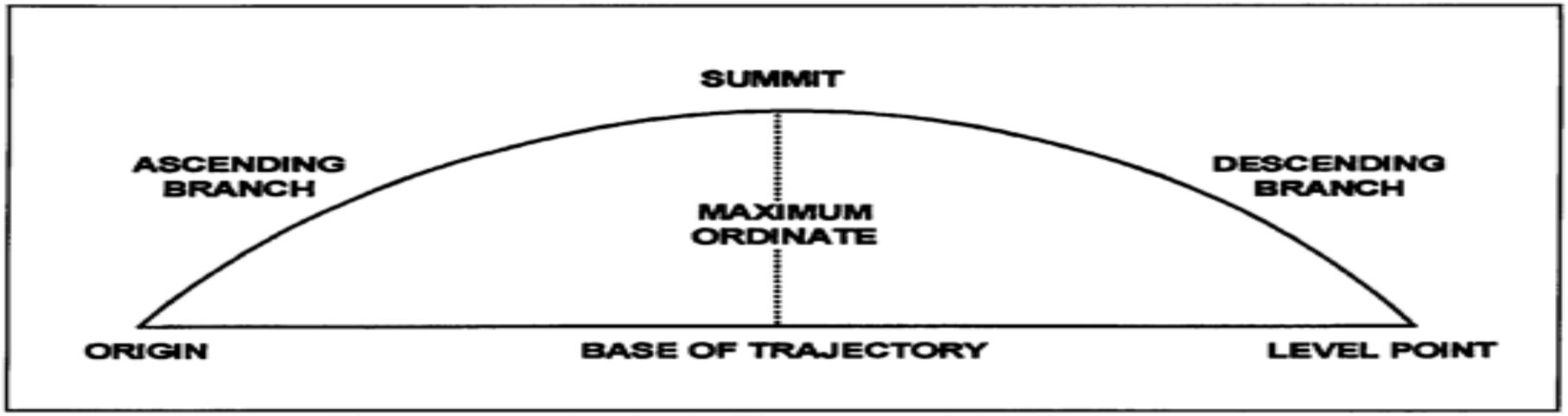


Figure 3-5. Intrinsic Elements of the Trajectory.

Branches of Trajectory

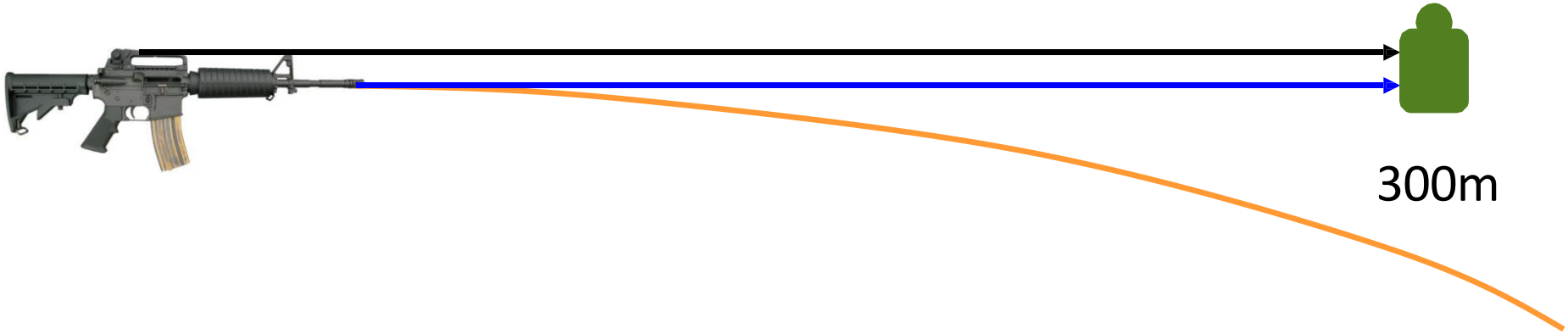
•**Rising Branch:** *The portion of a bullet's trajectory in which the bullet is rising due to the (AOD) of the rifle barrel. The rate of bullet rise is continuously decreasing due to gravity and drag (deceleration).*

•**Max Ordinate:** *Highest point in the Bullets trajectory.*

•**Falling Branch:** *The portion of a bullet's trajectory in which the bullet is falling from its max ord. The rate of bullet drop is continuously increasing due to gravity and drag (Deceleration).*

Trajectory

What has to change so that the bullet can hit the target?



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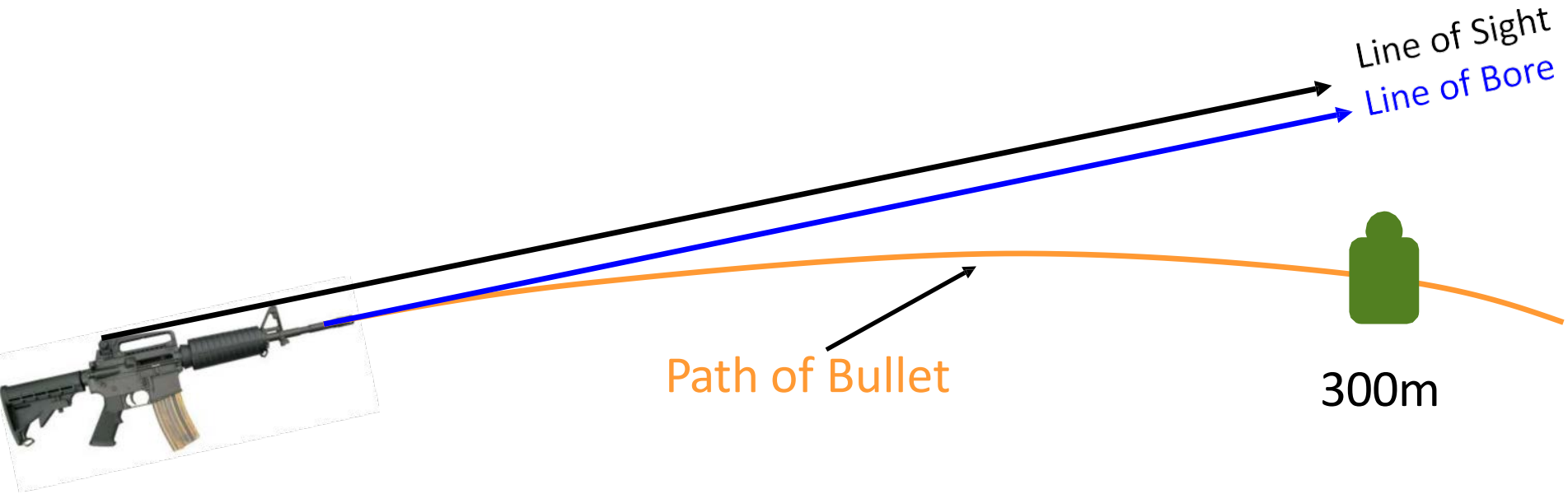
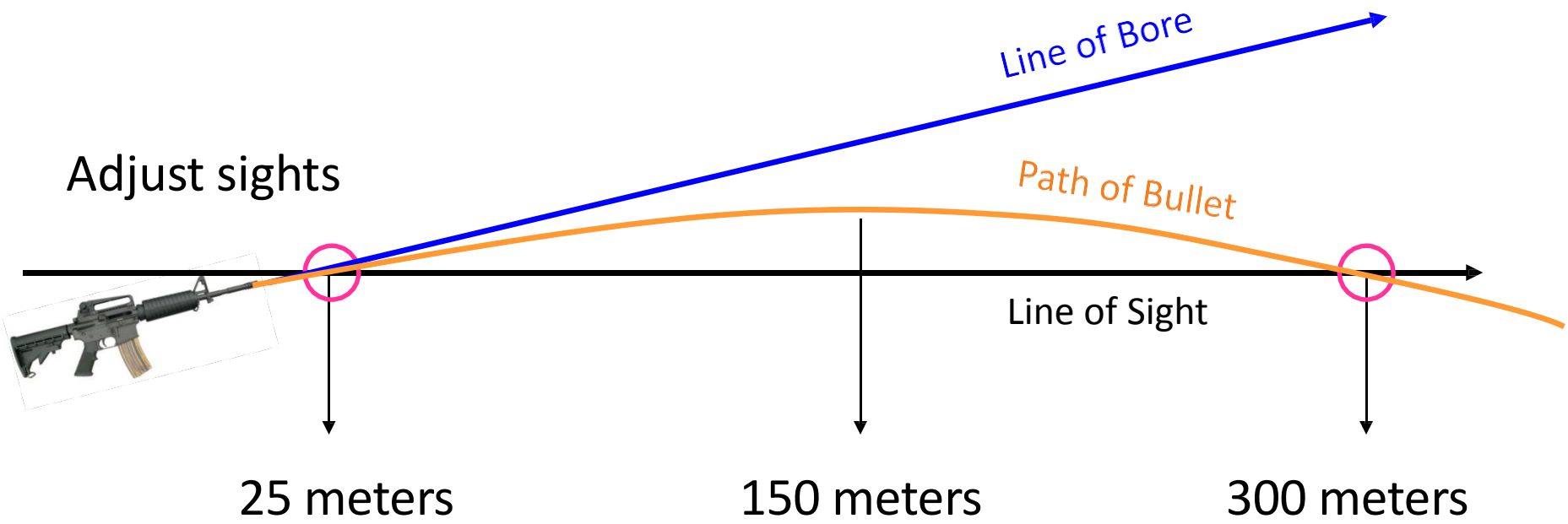


- Increase the angle of departure
- Raising the muzzle will cause us to lose sight of the target.
- This is why we adjust our sights. So that we can aim at the target and have enough elevation to hit it.

Trajectory


Line of Bore
Adjust sights
Path of Bullet
Line of Sight
25 meters
150 meters
300 meters