Single Munition Variable Velocity Non-Lethal Ballistic System for Fires Near the Muzzle to More Than 100 Meters

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Introduction

- Shoulder fired non-lethal point impact weapons are not very reliable beyond 30 meters.
  - decreasing probability of hit (P_h)
  - decreasing impact energy with range
- No point weapons beyond 50 meters only broad area, vehicle mounted systems

Individuals in crowds can initiate attacks from outside the accurate range of present NL point weapons

Effective point fires to beyond 60 meters is needed to provide safe standoff from hand and sling thrown weapons

Single Weapon/Munition Solution

- Needs to be effective from the muzzle to greater than 60 meters
- Needs a bounded impact effect
  - Impact velocity maintained within $\pm$ 5 m/sec. across the entire range of engagement distances
- Need to be accurate at all engagement ranges
  - $P_h > 90\%$
- Needs to be easy for the user to integrate
  - Simple operation
  - Small and lightweight

Decision to use Based on Risk of Significant Injury (RSI)

- RSI is used by commanders to determine if a non-lethal weapon **should** or **should not** be deployed.
- RSI is strongly influenced by **impact velocity and location**.
- Impact velocity decreases with range.
  - Reduces RSI and effectiveness.
  - Results are less predictable.
- Accuracy degrades with range increasing likelihood of undesirable effects:
  - Increased RSI from impact to the neck face or head.
  - Collateral damage (impact to bystanders).
  - Ineffective fires due to out right misses.
- RSI and effectiveness **vary** with range to the target

Pain Compliance Produces RSI

Balancing Effective Impact Velocity and RSI

- For each projectile there is a **minimum impact velocity** needed to achieve the desires level of pain compliance, varies across the body.
- For each impact location there is a **maximum impact velocity** that should not be exceeded (or there is a high probability of severe injury).
- In general the least vulnerable parts of the body are the heavy muscle groups of the legs and buttock.
- For consistency in training the aim point is center of mass.
  - **the torso the primary impact location**.
- "Safe" and effective impacts to the torso are also good against the extremities, **but impacts to face, neck, head, and groin likely produce sever injury**
- **Effective range of a weapon/munition is where:**
  - Impact velocity produce pain compliance with low risk of torso injury.
  - Accuracy is sufficient that aimed fire only impacts the torso and extremities >90% of the time.
  - Usually small 10 to 20 meters in length and **limited by accuracy decay**

Details:
Single Weapon/Munition Solution

- Impact effects must be bracketed.
  - Varying muzzle velocity with range to the target
- Impact location on torso and extremities.
  - Proper zero of the weapon
  - Accurate ranging
  - Articulation of weapon or site for correct zero at each range
- Fast to deploy, easy to opperate.
  - Modular accessory for M4 with regulation of lethal and NL site
  - Fire control for all complex actions:
    - Accurate ranging (to <5m accuracy)
      - Automated control of all range related weapon settings
      - Articulation of NL weapon to compensate for range and maintain regulation with lethal site

Battelle Variable Velocity Prototype

Battelle Variable Velocity Prototype

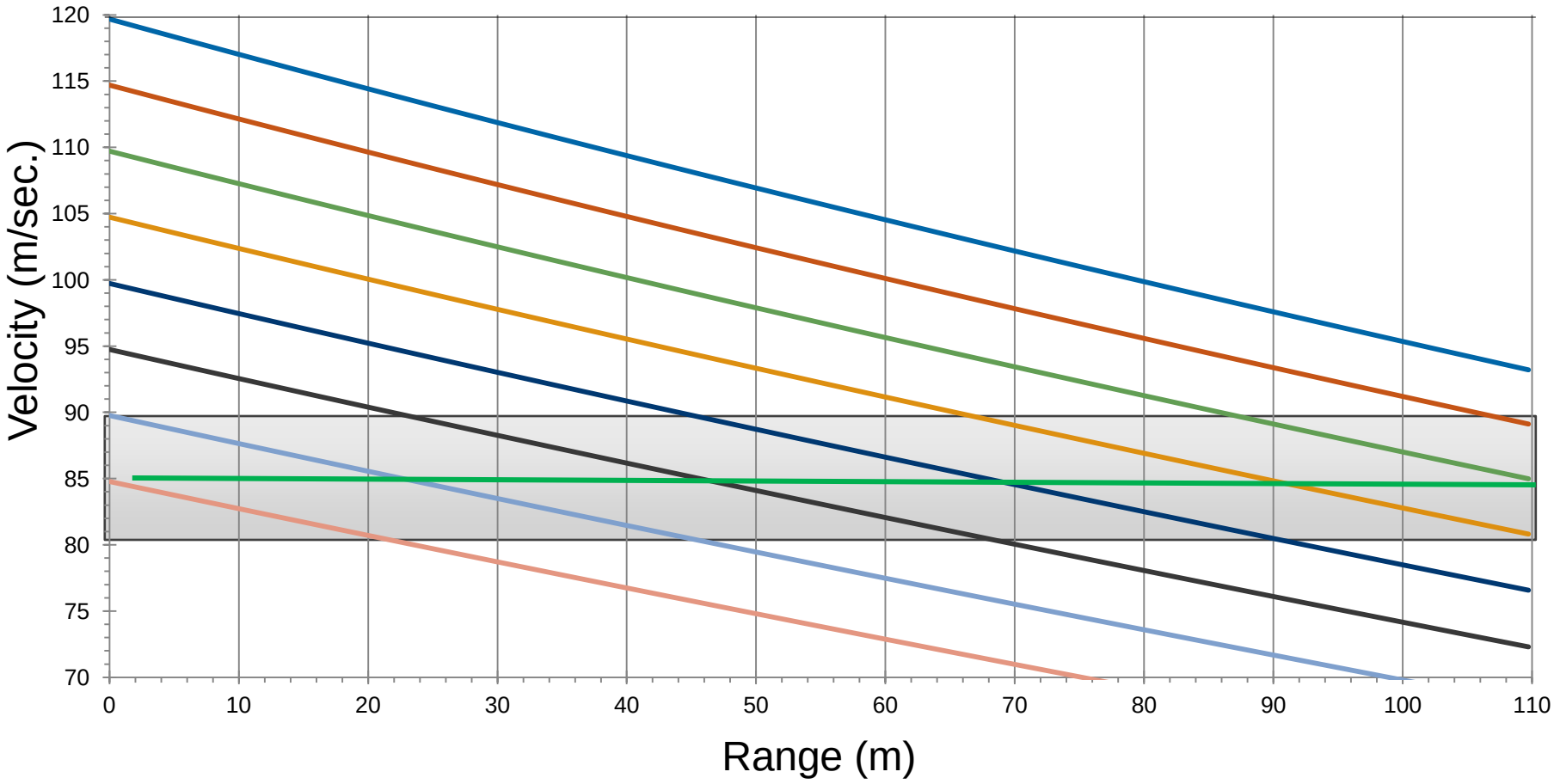
What is Needed for Accurate Fires

- A mechanically repeatable platform
  - With a match grade barrel
- Precise and repeatable sights
  - Adjustable for all shooting ranges
  - Knowledge of the range
- A munition with consistent muzzle velocity
  - Aerodynamic stability over the entire trajectory
- Shooter Skill

Doppler Radar Results

	Doppler Radar Data Measured by ARDEC ATF										
	High Velocity Mode									Low Velocity Mode	
	Raw Data			Group of 14 Shots			Group of 6 Shots			Raw Data	
	Velocity m/sec			Velocity m/sec			Velocity m/sec			Velocity m/sec.	
Shot	muzzle	30 m	100 m	muzzle	30 m	100 m	muzzle	30 m	100 m	muzzle	30 m
1	112.5	102.9	75.0	--	--	--	112.5	102.9	75.0	lost	lost
2	113.5	103.9	77.0	--	--	--	113.5	103.9	77.0	lost	lost
3	112.9	106.5	89.0	112.9	106.5	89.0	--	--	--	102.9	96.3
4	113.9	107.4	90.0	113.9	107.4	90.0	--	--	--	105.9	97.5
5	111.2	104.9	88.0	111.2	104.9	88.0	--	--	--	103.6	96.1
6	113.4	107.0	90.0	113.4	107.0	90.0	--	--	--	106.0	97.0
7	117.0	109.4	93.0	117.0	109.4	93.0	--	--	--	103.9	93.4
8	113.4	106.4	88.0	113.4	106.4	88.0	--	--	--	105.3	95.4
9	111.1	104.9	88.0	111.1	104.9	88.0	--	--	--	107.1	100.3
10	117.2	105.8	72.6	--	--	--	117.2	105.8	72.6	106.8	98.4
11	111.9	105.8	90.1	111.9	105.8	90.1	--	--	--	103.3	95.8
12	114.7	104.9	77.5	--	--	--	114.7	104.9	77.5	104.7	97.1
13	113.4	103.8	77.0	--	--	--	113.4	103.8	77.0	105.2	98.6
14	115.3	109.2	93.6	115.3	109.2	93.6	--	--	--	101.1	92.8
15	117.4	110.9	93.9	117.4	110.9	93.9	--	--	--	103.2	94.1
16	114.6	107.5	91.6	114.6	107.5	91.6	--	--	--	--	--
17	114.7	107.5	91.2	114.7	107.5	91.2	--	--	--	--	--
18	112.4	101.7	71.3	--	--	--	112.4	101.7	71.3	--	--
19	115.8	109.3	92.3	115.8	109.3	92.3	--	--	--	--	--
20	115.3	107.7	93.0	115.3	107.7	93.0	--	--	--	--	--
ave =	114.1	106.4	86.1	114.1	107.5	90.8	113.9	103.8	75.1	104.5	96.4
st dev =	1.9	2.4	7.7	2.0	1.8	2.1	1.8	1.4	2.6	1.7	2.1
extreme spread =	6.3	9.2	22.7	6.3	6.0	5.9	4.7	4.0	6.2	6.0	7.5

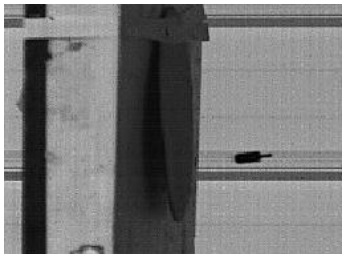
Keeping Impact Velocity Bracketed, Ideal Behavior

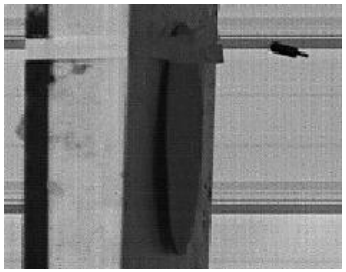


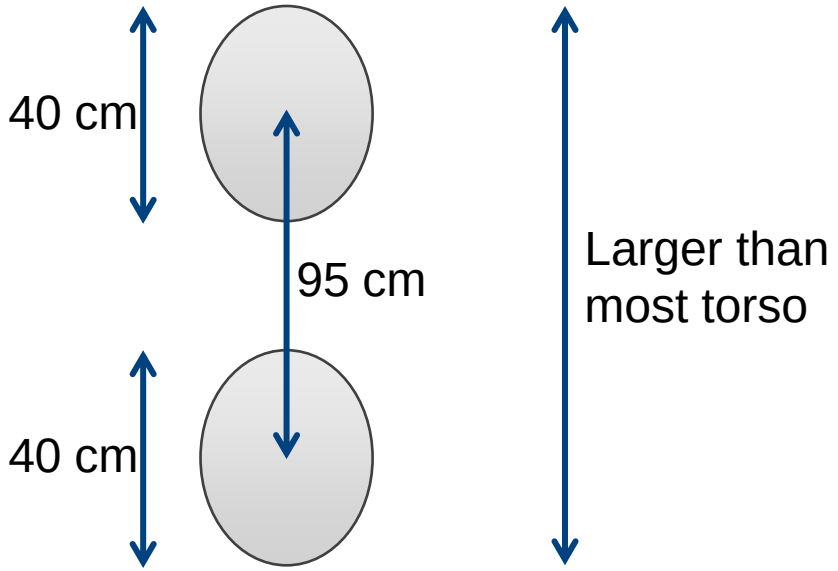
Vertical Dispersion at 100 meters

Low Yaw and High Yaw Rounds

- Extreme Spread approximately 6 m/sec.
  - Approximately ± 20 cm vertical dispersion
- Difference in average impact velocity approximately 15.5 m/sec
  - High yaw approximately 95 cm below low yaw





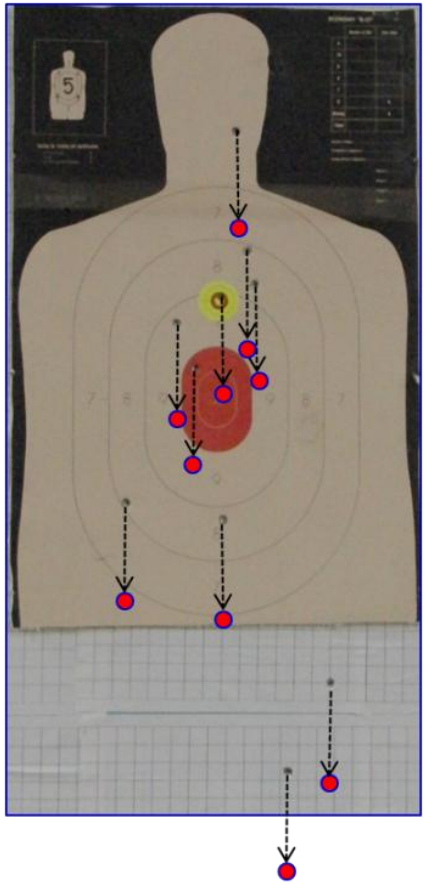


Dealing with Large Vertical Dispersion: Zeroing at Each Range

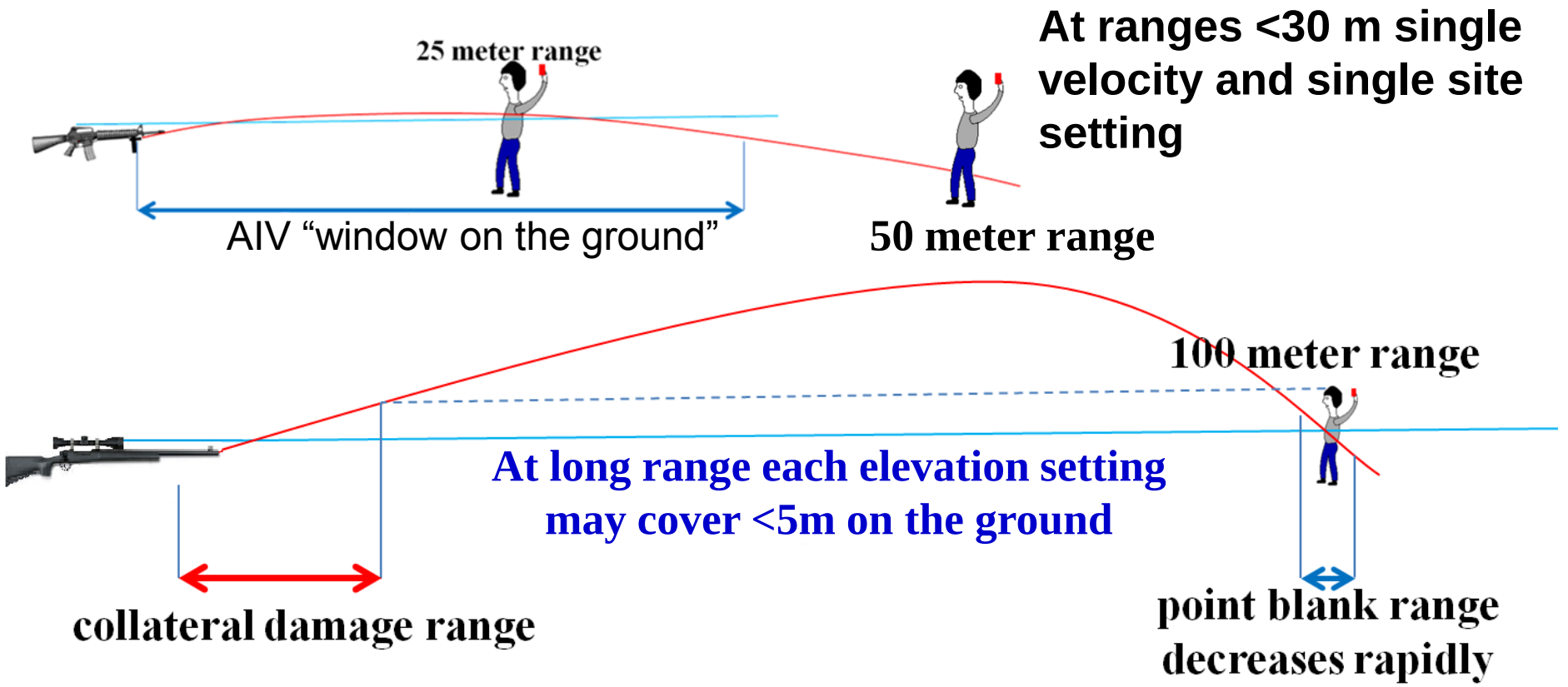
- Classic small arms zero: the geometric center of the group.
  - Works well when the group size is small.
- For large vertical dispersion placing the zero at the geometric center puts 50% of shots high.
  - Large risk of an impact to the neck, face, and head.
- For large vertical dispersion Weapon should be zeroed to the highest impact points of the group.

27 M zero to the average round

Zero at 100 M to the Most Aerodynamic Rounds



Arched Trajectory and Multiple MV



Each velocity setting may cover 25-30 meters, but at long range 2 to 6 elevation settings may be required for each velocity setting.

Multi-Muzzle Velocity Weapons Too Complex for Manual Control

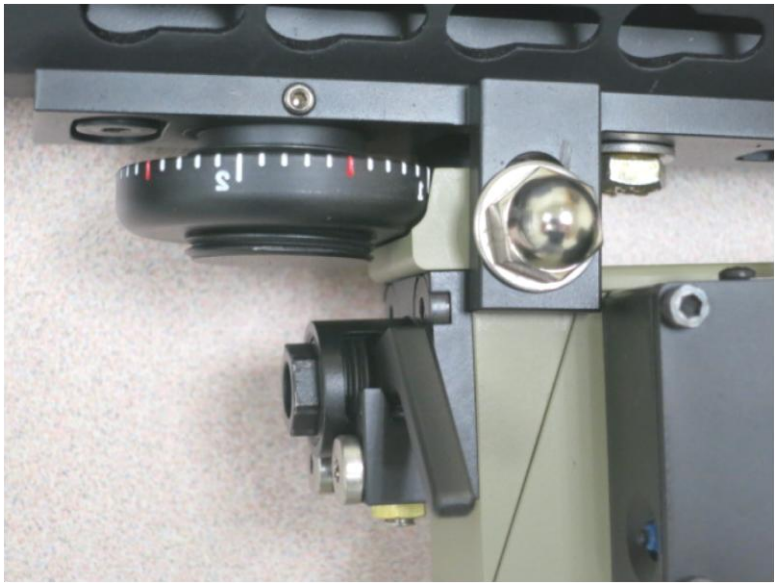
Accurate ranging, muzzle velocity selection, elevation adjustment: Too complex to do well under field conditions

- 4 to 5 muzzle velocities
- > 10 elevation settings
- Ranging resolution < 5 meters
- Environmental considerations
  - Wind
  - Temperature
  - Inclination

} **Fire Control**

Fire Controls are not Cheap

Non-Lethal Fires are a Small Subset of Small Arms Fires
Integrating Non-Lethal and Lethal Fires in One Control Distributes Cost Over Multiple Missions



Range target, electromechanically select muzzle velocity, electromechanically adjust NL weapon elevation regulating NL Point of Aim co-incident with Lethal Point of Impact

Single Site Setting for Lethal and Non-Lethal Fires.

Next Steps

- Improve aerodynamic stability preventing bi-modal terminal velocity and very large vertical stringing
- Develop a reliable auto-loading multi-shot
- integration of commercial fire control
  - articulation of non-lethal weapon (maintain NL impact coincident with parent weapon sight)
  - automatic selection of muzzle velocity based on user input of desired effect, environmental conditions and measured range to target
- Improved manufacturability of munition

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