Report Number: COTEC/SMC/2044/22

Comparison of UTM and GD-OTS SIMUNITION 'man marking' combat simulation ammunition.

SM Champion

June 2022

Cranfield Defence and Security
at
Cranfield University Ordnance Test and Evaluation Centre
Gore Cross, West Lavington, Devizes, Wiltshire, SN10 4NA, UK

EXECUTIVE SUMMARY

UTM Ltd contracted with Cranfield Ordnance Test and Evaluation Centre (COTEC) to conduct a series of trials to compare the safety features (to prevent firing wrong ammunition and wounding potential) of their Man Marking Rounds with respect to their market competitor GD-OTS SIMUNITION FX system.

All ammunition for the trial (both UTM and SIMUNITION) was supplied by UTM Ltd. The firearms were a mix of permanently modified firearms and adaptor kits, some of the firearms that the kits were fitted to were provided by the Defence Academy of the UK others were provided by UTM.

Despite the trial being paid for by UTM Ltd and the majority of the stores used also being supplied by UTM Ltd, the results of the trials conducted are faithfully presented within this report without fear or favour from UTM Ltd, any member of its staff or any other third party.

A number of combined strike velocity and penetration trials were undertaken with a variety of UTM and GD-OTS SIMUNITION combat simulation (man marking) ammunition with a variety of firearms from across the calibre spectrum. The safety attributes of both the UTM and SIMUNITION conversion kit systems was assessed along with their reliability.

The UTM Man Marking Round (MMR) system has demonstrated significant and apparently effective measures to prevent the accidental loading and/or firing of ammunition other than the UTM MMR ammunition. These measures are taken a step further than the GD-OTS SIMUNITION system where both FX and CQT ammunition can be fired out of the same conversion kits. This may be a significant differentiator between the two products safety profile in a training scenario where different types of training ammunition is present.

Both the UTM and SIMUNITION ammunition have demonstrated a low probability of penetrating human skin and therefore generating a permanent/long term injury. However, from shots fired at a volunteer's back (a member of UTM Ltd's staff) the UTM MMR ammunition has demonstrated over the limited number of shots to be consistently less injurious than the SIMUNITION FX ammunition.

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Date: 04th July 2022

Issued by:

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DISTRIBUTION

• UTM Ltd	2 copies
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1 INTRODUCTION

UTM Ltd contracted with Cranfield Ordnance Test and Evaluation Centre (COTEC) to conduct a series of trials to compare the safety features (to prevent firing wrong ammunition and wounding potential) of their Man Marking Rounds (MMR) with respect to their market competitor GD-OTS SIMUNITION FX system.

All ammunition for the trial (both UTM and SIMUNITION) was supplied by UTM Ltd. The firearms were a mix of permanently modified firearms and adaptor kits, some of the firearms that the kits were fitted to were provided by the Defence Academy of the UK others were provided by UTM.

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2 EQUIPMENT AND TRIAL APPARATUS

2.1 Skin Simulant

Build of target pack:

MDFPIM v2.1; 3 layers of 10mm foamed neoprene separated by 250 gauge polythene witness sheets, two layers 250 gauge polythene sheet on front face plus mounting film).

2.2 Weapons

- AR-15: Manufactured by LEI,
- C8 manufactured by Demarco (now Colt Canada)
- SA80: L85A2 TES, UK Service issue rifle
- AKM: Chinese Type 56 (permanent UTM conversion)
- GPMG: MAG 58 with UTM conversion,
- Glock 17: with UTM conversion
- Glock 17 with SIMUNITION conversion

2.3 Protective Equipment

- UTM full face mask with integrated goggles
- UTM full face helmet
- Avon FM53 respirator (with and without “outcert” lens cover)
- General Service Respirator (GSR)

2.4 Instrumentation

- Vision Research Phantom TMX 6410 high speed camera
- Chronograph with 300mm base length

3 SUMMERY OF RESULTS AND OBSERVATIONS

3.1 Velocities

The firearms in question were fired against the MDFPIM v2.1 skin penetration test target with the strike velocity being recorded using a Phantom NXT high speed video camera. A calibration video was filmed with a 1m rule in frame on the projectile trajectory, the camera or lens setting were not moved between the calibration video being taken and the videos of the projectiles o maintain the calibration. If for any reason the camera position or lens setting needed to be changed a fresh calibration video was taken for the measurement of subsequent projectile velocities.

The below data is averaged from several shot (5 or 10 were made from each firearm at each range, not all produced usable data for various reasons). The data from all shots can be found in tables in Annex A.

Firearm/Range		UTM average strike velocity	SIMUNITION average strike velocity
AK47	5m	68.2 m/s	Not Done
	10m	70.0	Not Done
	15m	67.3	Not Done

Firearm/Range		UTM average strike velocity	SIMUNITION average strike velocity
AR-15	5m	105.8 m/s	155.9 m/s
	10m	96.9	156.5
	15m	92.8	134.7
	20m	89.3	Not Done

Firearm/Range		UTM average strike velocity	SIMUNITION average strike velocity
C-8	5m	112.6 m/s	156.5 m/s
	10m	96.2	144.6
	15m	78.3	127.7
	20m	70.1	120.6

Firearm/Range		UTM average strike velocity	SIMUNITION average strike velocity
SA80	5m	98.5 m/s	83.74 m/s
	10m	87.1	127.4
	15m	73.2	109.7
	20m	52.7	96.6

Firearm/Range		UTM average strike velocity	SIMUNITION average strike velocity
GPMG	5m	98.8m/s	Not Done
	20m	50.0	Not Done

Firearm/Range		UTM average strike velocity	SIMUNITION average strike velocity
Glock 17	1m	92.6 m/s	119.5 m/s
	5m	83.1	110.6
	10m	73.9	102.1

3.2 Reliability

Before firing a reliability serial with either UTM MMR or SIMUNITION FX ammunition the firearm in question was cleaned and the barrel 'pulled through' several times to ensure it was both clean and dry.

3.2.1 UTM

No blockages of barrel occurred with any weapons when firing the UTM ammunition.

AR-15: Five stoppages from 210 rounds, 79, 165, 180, 186. All rounds fired on second strike. On stripping a small (almost imperceptible) bend was seen in the tip of the firing pin which may have been leading to 'light-strikes.

C8: 210 rounds from 30 round magazines, no stoppages

SA80: 210 rounds from 30 round magazines, no stoppages

AKM: 210 rounds from 30 round magazines, no stoppages

GPMG: One stoppage from 250 rounds (two 100 and one 50 rnd belt); round number 241 failed to fire (no strike on primer), round was extracted intact with no apparent damage.

Glock 17: 170 rounds from ten 17 round magazines, no stoppages

3.2.2 SIMUNITION FX

The SIMUNITION marking round commercial packaging recommends only putting 10 rounds in a magazine, but it was decided to load them to 30 to provide a fair comparison with the UTM system.

AR-15: First round failed to exit barrel, all other 209 rounds fired from 30 round magazines, no other stoppages.

C8: On magazine number 2 (round 56) there was a failure to feed with the round partially fed into chamber and partially jammed in magazine. On magazine (rounds 185 & 186) were stuck in the barrel. 210 rounds were completed.

SA80: The first stoppage occurred with the 4th magazine (round 115), the projectile became stuck in the barrel (see recovered projectiles in Figure 1).
From the 7th magazine; round 200 failed to feed, round 203 stuck in the barrel and round 205 failed to feed. 210 rounds total were fired.

Figure 1 - Recovered SIMUNITION projectiles that were stuck in barrel of SA80

Glock 17: On the 7th magazine the user reported it "didn't feel right".
The Glock was disassembled a broken round was discovered in the chamber unfired (see Figure 2) barrel was mis-aligned (see Figure 3) the barrel was adjusted to realign it into its proper position and firing continued.

Figure 2 - Broken 9mm SIMUNITION round

Figure 3 - Misaligned barrel of SIMUNITION kit

On the second round of the 8th magazine, the user again reported that something "didn't feel right" however on unloading the pistol a intact round was ejected from the chamber as would be expected and nothing was found amiss with the pistol. Firing continued.

After completing all 170 rounds the pistol was inspected and it was found that the barrel was again misaligned (see Figure 4).

Figure 4 - Misaligned barrel at end of firing

4 SAFETY

4.1 Protective equipment

One of the key aspects of combat simulation ammunition is safety. To investigate this aspect UTM ammunition was fired at close range (less than 1m) into various items that are sold by UTM ltd as protective equipment and service equipment that could be used as protective equipment during exercises.

The equipment is listed below with a description of the effects of being shot on that equipment and accompanying photographs. These tests were only carried out with the UTM MMR ammunition and not the SIMUNITION FX ammunition.

4.1.1 UTM full face mask with integrated goggles

Two shots were fired into the lens of the goggles. The shots did not damage the face mask in any way and only left waxy deposits in some places.

Figure 5 - UTM Facemask with integrated goggles after being shot with UTM ammunition

4.1.2 UTM full face helmet

Two shots were fired into the centre of the lens of the helmet. No damage was caused by either shot, only leaving waxy smudge at the impact point.

Figure 6 - UTM full face helmet after being shot twice with UTM ammunition

4.1.3 Avon FM53 respirator (with and without “outcert” lens cover)

Two shots were fired with the UTM MMR ammunition into the protective “outcert” lens cover of the FM53 respirator; one approximately of the non-curved portion of the cover (what would be in front of the eye) and the other was fired at the edge of the “outcert” cover near the bridge of the nose.

No damage was caused to the cover or respirator by the shots (the broken rim of the cover was pre-existing). Waxy debris from the shots can be seen on the bridge of the nose and on the lens.

Figure 7 – FM53 Respirator with "outcert" protective lens cover, after two UTM round impacts

Two shots were then fired at the unprotected respirator lens. Again, no damage was caused to the respirator.

Figure 8 - FM53 Respirator without "outcert" protector, after two UTM round impacts

4.1.4 General Service Respirator (GSR)

As with the FM53 respirator, two shots of UTM MMR ammunition were fired into the GSR at close range, one into the area approximately over where the users eye would be and the other at the edge of the lens adjacent to the side of the nose piece. No damage was caused to the respirator, leaving only waxy debris from the impacts.

Figure 9 - General Service Respirator after two impacts from UTM ammunition

4.2 Wounding potential

Measuring injury potential is not trivial. There have been many studies (including by this author) into the wound ballistics of ammunition intended to be lethal (or to be more correct; to be incapacitative by likely lethal means), usually using 'ballistic gelatine', though other materials have also been used particularly formulations of glycerol soap[1]. These simulants are often used to provide a suitable target to determine wounding potential, this is appropriate for penetrating ammunition where the long wound profile demonstrates the interaction between the projectile and the simulant.

In the case of combat training ammunition the intent is not to generate a deep penetrating wound, indeed the intent is to be as non-wounding as possible while still providing the participants encouragement not to get shot and thus providing safe high value training. This rules gelatine out as a suitable wounding measure as gelatine represents muscle tissue, not skin. Dr Gregory James carried out an extensive survey of existing research and then conducted experiments to close the gaps in that research into skin penetration models as part of his doctoral thesis[2]. From his research James designed and then calibrated a number of physical models to be used in a) penetration testing, b) skin penetration testing and c) corneal damage testing. James refers to the model designed for skin penetration testing as MDFPIM v2.0.

The comparison of the 'skin' V50 vs the projectile section density was plotted by James for the MDFPIM v2.0, the 'Adult Human Population' and 'Vulnerable civilian population' as way of showing the consistence of performance. The 'Adult Human Population' and 'Vulnerable civilian population' models were derived from post-mortem human skin and animal tissue experiments. The criteria used to measure against the tissue derived data was that if a projectile penetrated through 2 layers on the 10mm foamed neoprene then the same projectile would have had a 50% chance of penetrating human skin. The results of this analysis do indeed show good corelation between the MDFPIM v2.0 physical models and the tissue derived experimental data within 95% confidence intervals (see Figure 10).

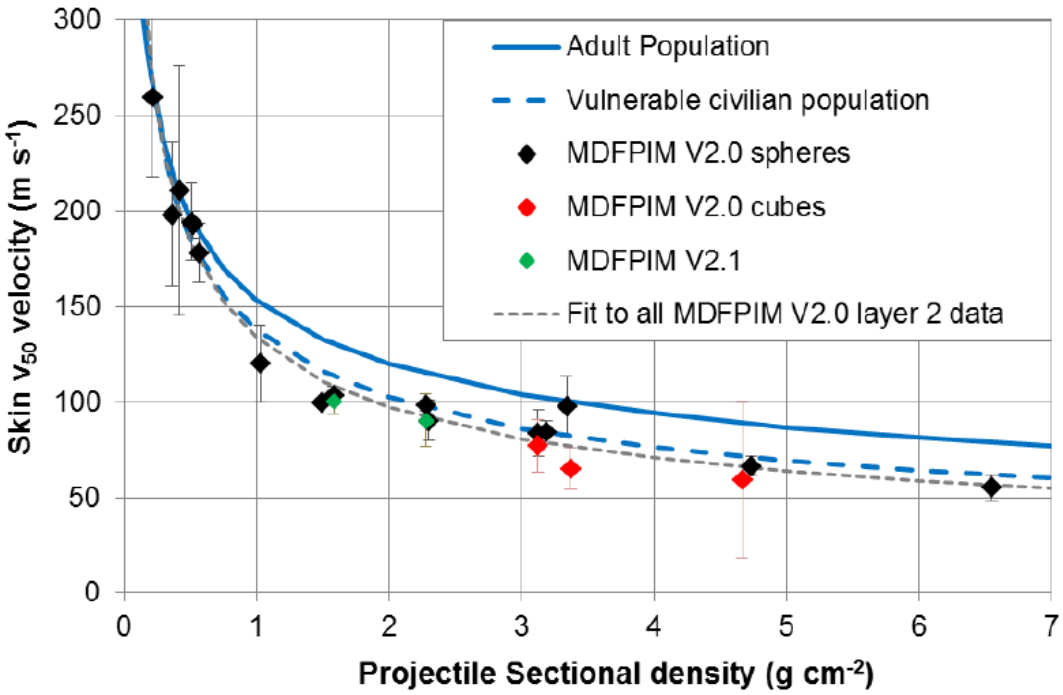

Figure 10 - MDFPIM v2.0 calibration vs data derived from tissue samples, reproduced from James' PhD theses[2, pp 327]

Given the above agreement between model and experimental data and the considerable amount of supporting analysis James had presented it was considered that the MDFPIM v2.0 physical model would be an excellent fit for the wounding potential analysis that was at hand with the UTM MMR and SIMUNITION FX ammunition.

4.2.1 Data generation

For all of the firings conducted to measure the strike velocity of the projectiles fired from different ranges they were fired at a MDFPIM v2.0 target.

This equated to 84 rounds of 5.56mm, 25 rounds of 7.62mm and 15 rounds of 9mm UTM projectiles from distances of 5 to 20m for the 5.56 and 7.62mm and 1 to 15m for the 9mm.

The same was performed with the SIMUNITIONS FX ammunition. A total of 71 rounds of 5.56mm and 15 rounds of 9mm were fired into the test target

4.2.2 Results

From all the rounds fired the 5.56mm projectiles from either the UTM or the SIMUNITION ammunition were the most penetrative, with most of the 7.62 and 9mm projectiles not fully penetrating the first layer of foamed neoprene and none penetrating the polyethene witness sheet between the first two sheets of foamed neoprene. Therefore, it is indicated that the 9mm and 7.62mm UTM or SIMUNITION FX man marking projectiles have a substantially less than 50% chance of penetrating bare skin.

With the 5.56mm projectiles the test targets for the SA80, C8 and AR15 tests were unremarkable with both UTM and SIMUNITION projectiles not penetrating through to the rear face of the second foamed neoprene layer. Witness marks were evident on the following polyethene sheet, but they were stretch/indentation marks probably from the projectiles compressing the neoprene and stretching the polythene rather than puncturing it.

Figure 11 - 5.56mm fired projectiles recovered from test targets, SIMUNITION FX (left) and UTM (right)

A principal difference between the 5.56mm projectiles and the others is the 5.56 projectiles did significantly penetrate through the first layer and deep into the second layer of foamed neoprene. Whereas the larger calibres did not reach the second layer.

A member of UTM staff volunteered to be shot with both their MMR ammunition and the SIMUNITION FX ammunition. A total of six shots were fired into their back at a range of 5m with the AR15 rifle. The first 3 were SIMUNITION FX ammunition; first with two layers of clothing (current uk issue pattern combat shirt and light jacket); second with one layer of clothing (the issue combat shirt) and third onto bare skin. The same three scenarios were then repeated with UTM rounds.

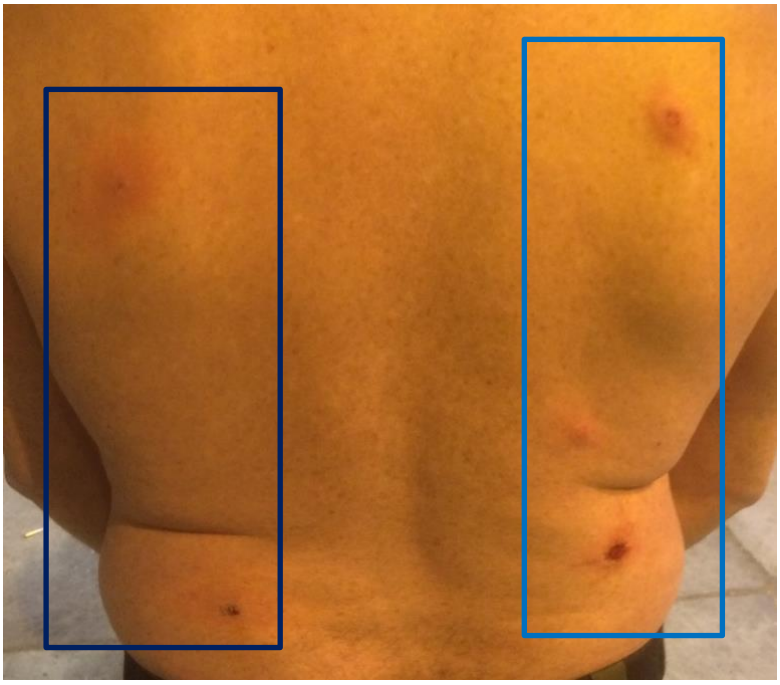

Figure 12 - Impacts of Man Marking rounds onto the volunteers back

Figure 13 - Close ups of impacts onto bear skin at the same scale, UTM (left) and SIMUNITION FX (right)

4.2.3 Wounding discussion and summery

From the evidence of the MDFPIN v2.0 test targets the conclusion can be drawn that the wounding potential of the two manufacturers' man marking ammunition is comparable and below the threshold of causing permanent harm. Against the volunteer's back the impact points between the UTM and SIMUNITION FX 5.56mm ammunition were at equivalent anatomical areas so the contusions are directly comparable. It is clear for the three different impact scenarios the SIMUNITION FX ammunition produced slightly worse injuries than the UTM MMR ammunition when fired at the same range from the same firearm.

Comparing the test target and volunteer's back, the bottom two strikes (one of each ammunition) did break the skin but did not penetrate to any degree. The shots with both 5.56mm ammunition natures against the test target at the same range from the same firearm gave an indication that the probability of these rounds penetrating the skin was less than 50% (did not breech the rear of the second foamed neoprene layer).

4.3 Observations on the ammunition systems' safety

It was noted that the slide of the SIMUNITION conversion kit for the Glock pistol that the kit was compatible with both the Man marking FX ammunition and the CQT ammunition (see Figure 14). The CQT ammunition is stated in SIMUNITION's Handling and Safety Instructions for the Glock 17 conversion kit to be "Not for use against human targets"[3], however any potential skin penetration or other hazard the CQT ammunition may present was not assessed as part of this trial.

Figure 14 - Text on the side of the Glock 17 SIMUNITION slide

The UTM system uses separate bolts/slides for its Man Marking Round (MMR) and their 'Target Bullet Round' (TBR) to eliminate the potential issue of a TBR being inadvertently fired out of a MMR converted firearm. The TBR ammunition cannot be fired from the MMR conversion kits/systems. This is achieved by recessing the primer of the TBR ammunition so that the firing pin from anything other than a TBR conversion kit cannot strike the primer.

Figure 15 - Bases of UTM Man Marking Rounds (left) and Target Bullet Round (right)

The UTM MMR system was loaded with a 'live' round (live primer no propellant) and fired. Due to the rim-fire nature of the UTM ammunition that the kits are designed to fire the firing pin struck the very edge of the live primers and thus did not initiate the round, but left a visible 'tell-tail' mark (see Figure 16).

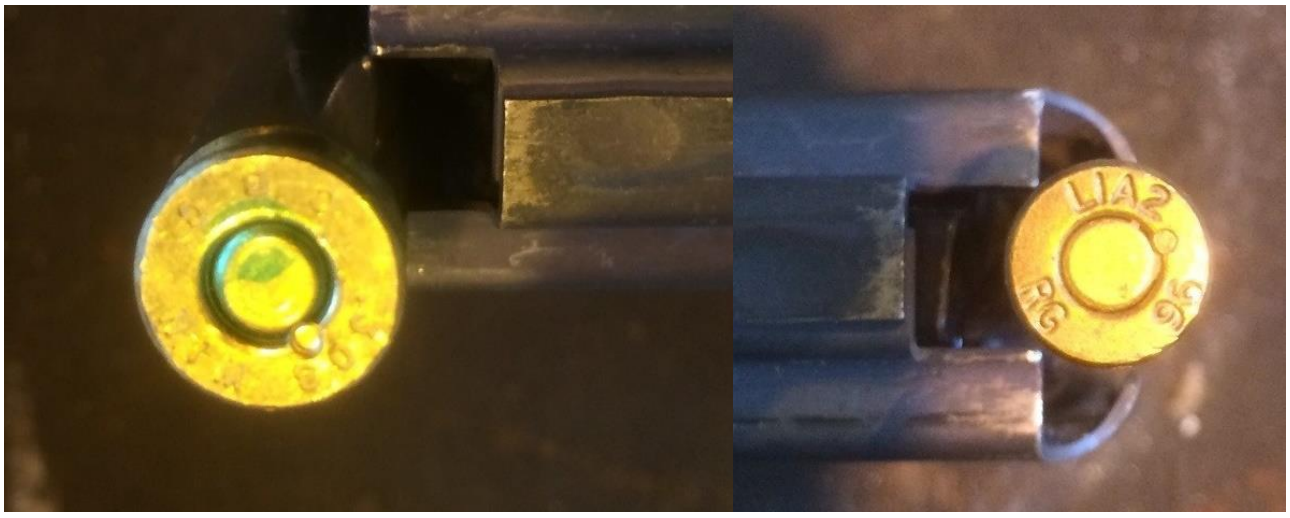

Figure 16 - Live ammunition 'fired' in UTM MMR kits 7.62x51mm (left) and 5.56x45mm (right)

Other observations related to safety relate to the look of the different ammunitions, where the SIMUNITION FX ammunition is made of a brass cartridge case, the same as blank and live ammunition, UTM uses aluminium which provides for a distinct appearance.

Figure 17 - Comparison of visual appearance on UTM (top), service blank (middle) and SIMUNITION FX (bottom) ammunition in 5.56mm

When a live round was loaded in to the Glock 17 fitted with the UTM MMR kit, the slide would not close, and therefore the Glock firing mechanism would not function.

Figure 18 - Glock 17 with UTM kit loaded with live round of 9mm ammunition.

Similarly, the UTM conversion kit for the GPMG (FN MAG 58) physically prevents the loading of live ammunition.

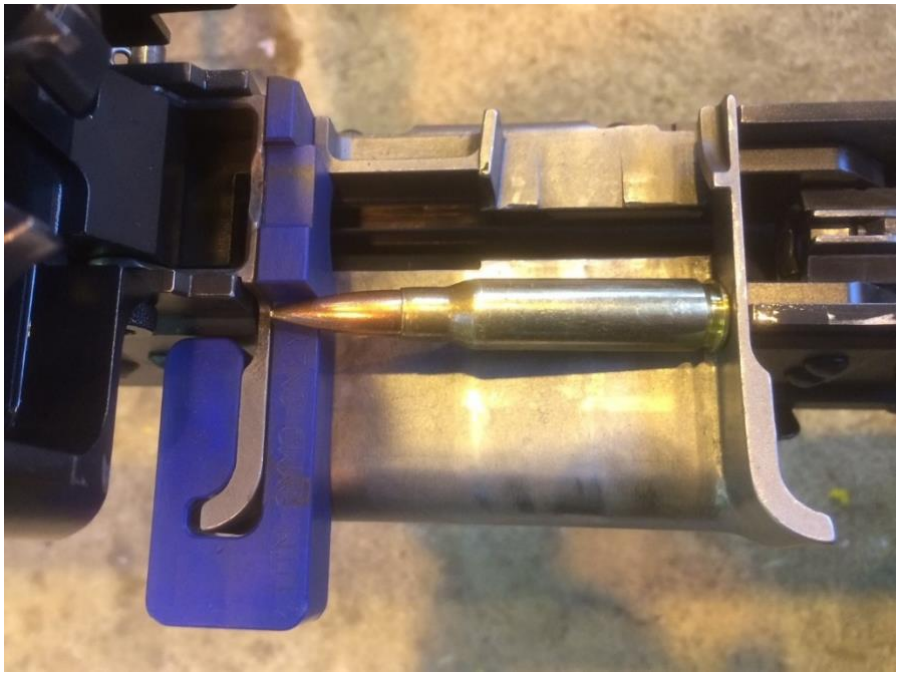

Figure 19 - FN MAG 58 with UTM conversion kit preventing the loading of live 7.62x51mm ammunition

5 CONCLUSIONS

SIMUNITION FX ammunition was shown to have higher strike velocities then the UTM MMR ammunition at all ranges and for all firearms tested.

The UTM MMR system has demonstrated significant and apparently effective measures to prevent the accidental loading and/or firing of ammunition other than the UTM MMR ammunition. These measures are taken a step further than the GD-OTS SIMUNITION system where both FX and CQT ammunition (which GD-OTS state themselves should not be fired against personnel) can be fired out of the same conversion kits. This may be a significant differentiator between the two products' safety profile in a training scenario where different types of training ammunition is present.

Both the UTM and SIMUNITION ammunition have demonstrated a low probability of penetrating human skin and therefore generating a permanent/long term injury. However, from shots fired at the UTM volunteer's back the UTM MMR ammunition has demonstrated to be less injurious than the SIMUNITION FX ammunition. It must be bourn in mind that this experiment was of a very low number of repeats, but the results of all shots done was consistently in UTM's favour.

REFERENCES

(1) Kneubuehl B. et al. Wound Ballistics: Basics and Application (English Translation), Springer 2011. ISBN 978-3-642-20355-8

(2) James G. Development of models to assess penetrating injury from ballistic projectiles, PhD Thesis, Cranfield University 2019

([3]) Training for the real world – SIMUNITION conversion kit for Glock 17-22 GEN III Improved Pistols, Product No. : 5312600, Handling and Safety Instructions. Ref No. 5312601.FTSIM (rev. 00) available at: https://simunition.com/upload/products/conversion_kits/feuilleTechnique_en_106.pdf (retrieved 29/06/2022)