HIPERFIRE® Trigger Families

Radical Sear Mechanics™ (RSM)

Introduction

Today, shooters of the Modern Sporting Rifle (MSR), the ubiquitous multi-caliber AR15/10 (AR) platform, have been demanding lighter trigger pull weights provided by typical 7-9 lbs. so-called MIL-spec triggers.

Most shooters would agree that lower weight is the primary criterion for choosing a trigger upgrade, but there are other wants like less creep, reduced or no grit "feel," clean and crisp break, to name a few. A survey of available trigger upgrades from MIL-spec shows that many of the better after-market triggers satisfy some of these wants, but not all. Shooters have found that some of these wants are mutually exclusive and that makes the ideal trigger an impossible reality.

In this HIPERTECH (HI-gh PER-formance TECH-nology) bulletin, we begin to explore how and why the HIPERFIRE trigger families (HIPERTOUCH®, HI-gh PER-formance TOUCH, and EDT®, ENHANCE DUTY TRIGGER®s) more nearly realizes Everyman's desire for that ideal AR trigger. Future HIPERTECH white papers continue the exploration into every factor that influences what constitutes an excellent trigger, what should satisfy all the critical criteria or metrics, that we can identify, as scandalous to many fans of popular triggers as that may be. What we have found may surprise you.

The information provided is accurate to the best of HIPERFIRE's knowledge. Any experimental data presented has been collected and analyzed using commercially available test instruments, software, and products, subject to the application of the scientific method and engineering knowhow, so that anyone familiar with the art could reproduce and verify the results. The interpretation of that data is not necessarily definitive, but of HIPERFIRE's considered opinion.

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Radical Sear Mechanics™ (RSM)

The starting point for this phase of HIPERFIRE's trigger developments began with the 50-cal. trigger introduced in HIPERTECH #1. The "weird-looking trigger" with the Cam-Over Toggle Engine™ or COTE. As noted at the end of that bulletin, the 6-7 lb. trigger pull weight was still too high, however, much lighter than the 50-BMG's initial 10-12 lbs. Let's continue that discussion about HIPERFIRE's trigger discoveries.

Trigger pull weight is determined by 1) spring forces and 2) the trigger and hammer sear arrangement that affects the impingement force on the sears. We experience this weight as a byproduct of friction. <u>Friction is still the enemy of achieving low pull weights while maintaining high hammer strike power</u>. Obvious, you say! If it is so obvious, why do all other triggers tend to look the same? High friction and high pull weights yield high hammer power. Low friction, low pull weights, hammers light-strike, or fail-to-fire. Nothing's changed. HIPERFIRE's focus was still on reducing sear friction.

Tribology is the study of friction, or wear between components that slide against one another. Creep, a bad word for most AR trigger aficionados, is just the sliding of one metal, a trigger, on another, the hammer. It's how that feels on the trigger finger that gives the technical term a bad rap. For our purposes, we use the term creep in its technical sense, not prejudging it good or bad for the time being. We explore whether using the friction component of creep to our advantage can make it our friend.

Now friction depends on many factors. We know from Tribology that impingement force is one of those factors. Others include the material(s), its hardness or softness, the surfaces' finish, the distance over which the sliding occurs, the shape and size of the contact area, the speed of sliding and whether it's intermittent or continuous, the influence of hot and/or cold temperatures, the numbers of sliding cycles as that may affect the finish over time, any lubrication and of what type that may be employed, etc. We refer the reader to an article on friction at https://en.wikipedia.org/wiki/Friction#History for more details we won't go into here. Suffice to say; the impingement force is the factor that most influences trigger sear friction. Powered machinery forces are usually fixed, for example. So, the designer must wrestle with the other factors that contribute to friction. Limiting ourselves to trigger design, we saw that we could reduce sear friction best with a new force reduction approach. Well, as employed on a trigger, it was just Engineering Mechanics 101. We were amazed no one ever looked at AR triggers this way before. How long have they been around?

Eugene Stoner's original AR-15® rifle and all subsequent variations used a stiff hammer spring to reliably touch-off MIL ammo. That heavy spring also meant high sear friction and high pull weights. The high pull weight was rationalized to provide adequate safety on the battlefield during the stress of engagements by minimizing accidental discharges. All would agree today that it also resulted in poor rifle accuracy — the bane of the AR. Figure 1 shows the AR15 sears' mechanical advantage characteristics.

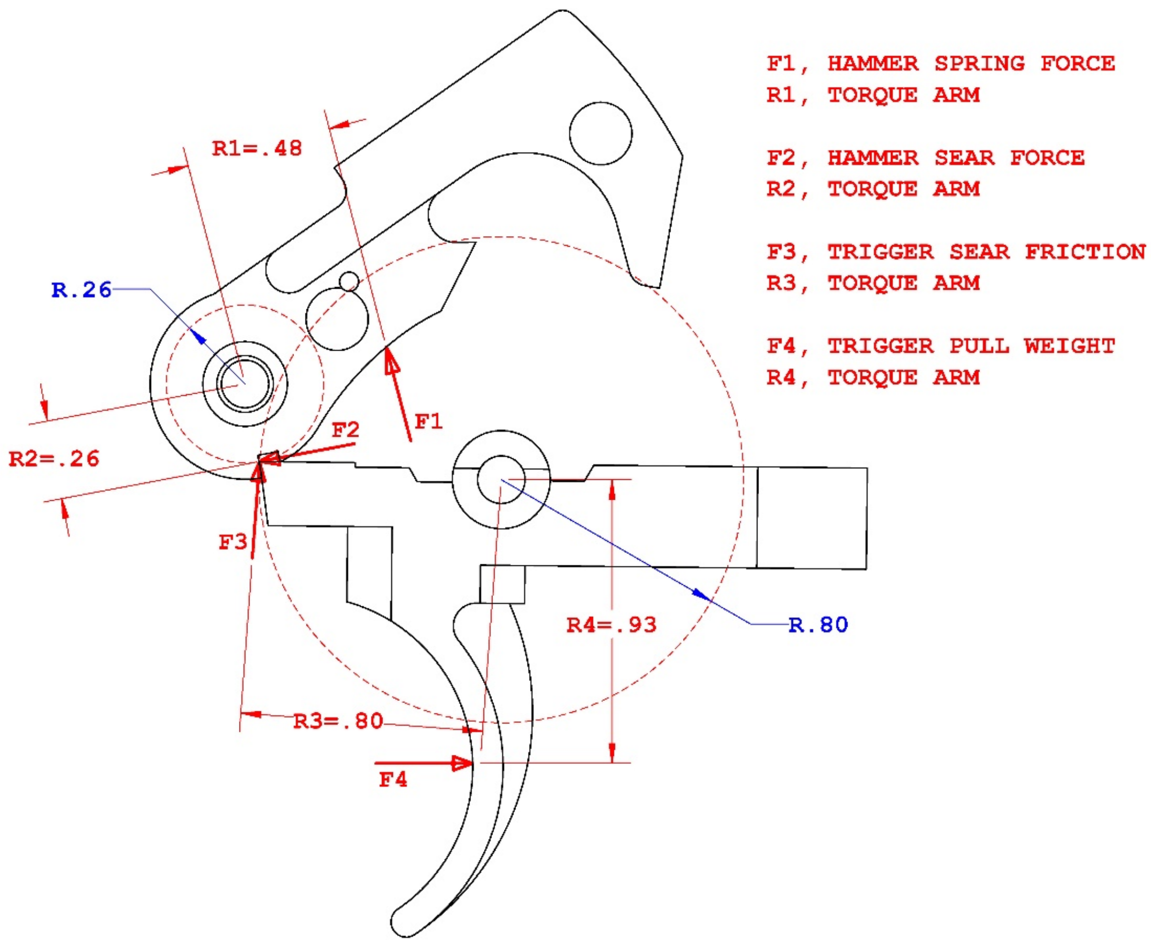

Figure 1. The MIL-spec trigger's mechanical advantage is shown with important dimensional information used to calculate pull weight.

HIPERFIRE changed the positional arrangement of the trigger and hammer sears shown in Figure 1 to what's shown in Figure 2 to deliver lower pull weights. The mechanical advantage between the trigger and hammer sears is changed. Fundamentally, we changed the leverage between the parts to reduce impingement forces; remember the Engineering Mechanics 101 course? By so doing, we reduced friction and the pull weight.

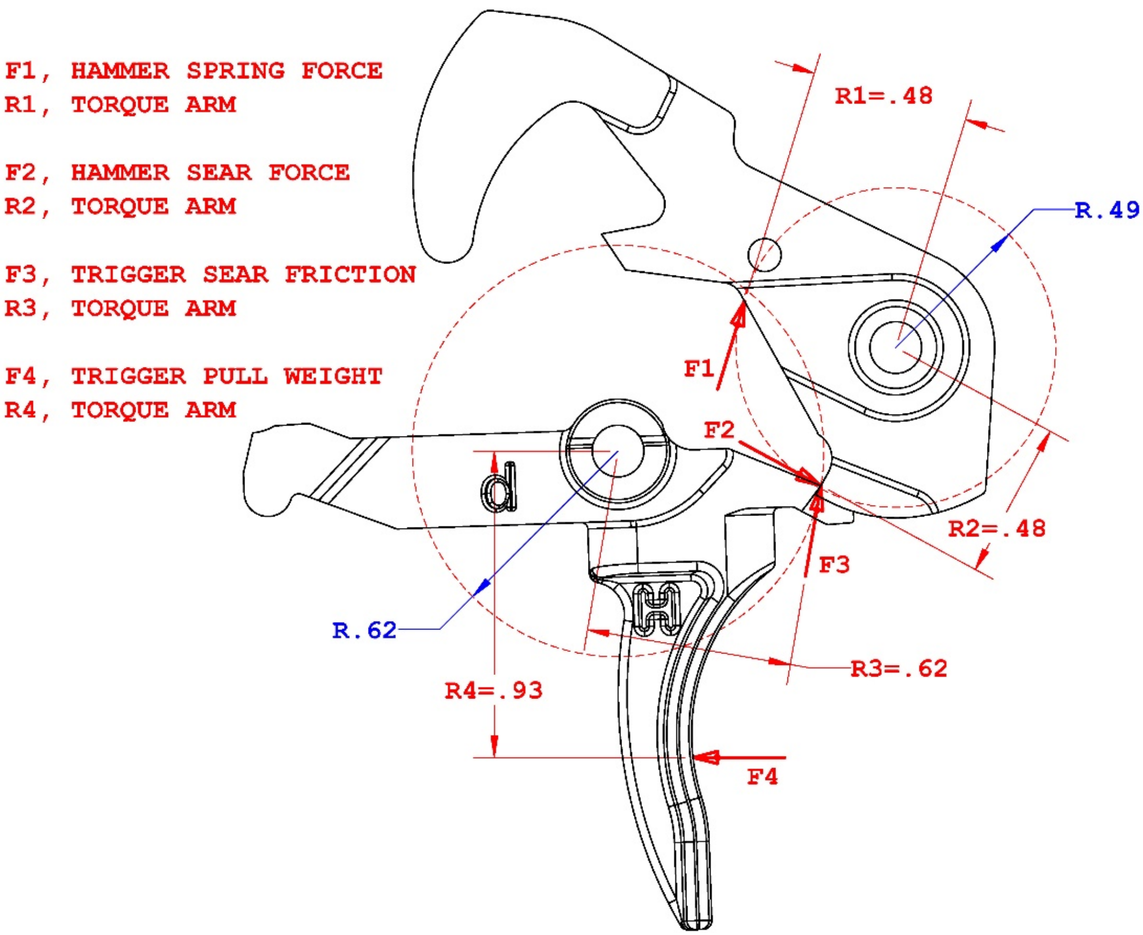

Figure 2. A HIPERFIRE EDT pull-weight mechanical advantage with important dimensional information used to calculate pull-weight.

Figures 1 and 2 show the derivation of the force vectors from which is derived the pull force for the MIL-spec trigger and a HIPERFIRE Enhanced Duty

Trigger®. Both use the same hammer spring and trigger spring (keeping all other factors equal, comparing apples to apples). The following are sample calculations showing the difference that sear mechanical advantage can make on the trigger pull weight for the MIL-spec trigger versus HIPERFIRE EDT.

The larger the mechanical advantage number, the lower is the trigger weight (all other trigger friction factors being equal, like hammer spring force, material, surface finish). Let's make the initial calculation very simple without calculating a pull weight directly from the forces, torques, and a friction value.

Let's look at Figure 1 again. Note the MIL-spec sear pivot radiuses. The ratio of R.26-inch to R.80-inch represents the respective leverages of the MIL-spec trigger and hammer sears that are used in our calculation. So, divide .26 by .80 equaling .33, the MIL-Spec mechanical advantage between hammer and trigger. Now view Figure 2 again and note the same corresponding ratios of R.49-inch to R.62-inch and we can calculate the EDT mechanical advantage between hammer and trigger as .49/.62 equals .79. The higher mechanical advantage value of the EDT should mean a lower pull weight compared to the MIL-spec. Let's do the calculation. Assume that the MIL-spec pull weight is 8.5 lbs., ratiometrically then, the pull for the EDT would be approximately 8.5 times the ratio of .33 to .79, or (8.5)x(.33)/(.79) equals 3.6 lbs. That's how the much-improved mechanical advantage of the EDT over the MIL-spec trigger lowers the pull weight, with nothing else changing
except for the mechanical advantage geometry.

Consider for a moment that all the other friction factors are equal again, but let's calculate the pull weights directly this time using the equations immediately below.

$$\text{Torque by definition, } T = FR \qquad (1)$$

$$T_{input} = T_{ouput}, \text{ within a component.} \qquad (2)$$

$$\text{Friction Coefficient, } e = \frac{F_f}{F_N} \qquad (3)$$

The variable **e** describes the value of friction used in our calculations. It's determined experimentally for various materials and their surface conditions. It's a significant quantity, derived from F_f , the Friction Force, divided by F_N, the “normal force,” or impingement force. Substituting (1) into (2) and solving for **F2**, the hammer sear force, we get (4), (5), and (6).

$$T1 = T2 \tag{4}$$

$$F1R1 = F2R2 \tag{5}$$

$$F2 = \frac{F1R1}{R2} \tag{6}$$

Now, **F2** is the hammer sear force, referred to here as the “normal force,” or impingement force, applied by the hammer sear onto the trigger sear. Normal means that the vector is applied at a right angle, or is perpendicular to the contact hammer surface. Close inspection of Figure 1 shows that the force is not normal. However, we proceed as if it were to simplify the calculation and make our comparison easier to follow.

The friction force, **Ff,** is identified in Figure 1 as **F3**. That's the force that the trigger is pulled against, equation (3). Rewriting (3) as (7) and solving for **F2** yields equation (8) giving us the relationship between **F3** and **e**.

$$e = \frac{F3}{F2} \tag{7}$$

Solving (7) for **F2** we get

$$F2 = \frac{F3}{e}. \tag{8}$$

Substituting equation (8) into (6) gives equation (9). Solving (9) for **F3** yields equation (10).

$$\frac{F3}{e} = \frac{F1R1}{R2} \tag{9}$$

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$$F3 = \frac{eF1R1}{R2} \qquad (10)$$

Deriving the trigger's equation for **F4** in the same way as (6) was derived for the hammers **F2** we get

$$F4 = \frac{F3R3}{R4}. \qquad (11)$$

Substituting equation (10) for **F3** into equation (11) and solving for **F4**, which is the pull weight yields equation (12).

$$F4 = \frac{eF1R1R3}{R2R4} \qquad (12)$$

Now let's solve for a hypothetical MIL-spec pull weight based on the various inputs from Figure 1. Let's assume that the value for the friction coef., **e**, is **0.65**, (this is typical and in the range of values, 0 to 1, for steel on steel) and the hammer spring force is 8.5 lbs. Rewriting (12) as (13) by substituting the values represented for their variables and calculating we find that the MIL-spec trigger pull weight is 8.1 lbs.

$$F4 = \frac{(0.6)(8.5\ \text{lb.})(.48\ \text{in.})(.80\ \text{in.})}{(.26\ \text{in.})(.93\ \text{in.})} \qquad (13)$$

$$F4 = 8.1\ \text{lbs.}$$

8.1 lbs. is in the typical 7-9 lb. pull-weight range for MIL-spec triggers. Now let's see what an EDT trigger's mechanical advantage would provide if using the same MIL-spec hammer spring and the same friction coefficient, i.e., everything being equal but the mechanical advantage for the EDT's RSM. We use the **R** values shown in Figure 2 to calculate the EDT's trigger pull weight, **F4**, from equation (12) as EDT trigger pull weight equation (14).

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$$F4 = \frac{(0.6)(8.5\ \text{lb.})(.48\ \text{in.})(.62\ \text{in.})}{(.48\ \text{in.})(.93\ \text{in.})} \qquad (14)$$

$$F4 = 3.4\ \text{lbs.}$$

3.4 lbs. is a lower pull weight compared to MIL-spec by half! That is pretty close to the 3.6 lbs. calculated the easy way further above. Unfortunately, all other factors are not equal (like the "normal force," the coefficient of friction) so the mechanical advantage is not precisely proportional in this way, but good enough to make the point. The actual EDT weight comes in around 4½ lbs., a pound higher than what these two simple calculation methods yield. So, we can declare that mechanical advantage does matter, that just a geometry change and nothing else easily controls trigger pull-weight.

Contrast this to how some other trigger manufacturers reduce trigger pull weight. They reduce the power of the hammer spring to reduce that troublesome sear friction, sometimes too much, causing light-strikes, or FTF (failure to fire). In contrast, HIPERFIRE uses a MIL-grade hammer spring. Others, separately or in addition to lightening the hammer springs to lower friction and weight, finish grind, EDM wire machine, or polish the sear surfaces after the fact, to make up for poor mechanics, but with diminishing returns. Customers often manually polish the sear surfaces of their trigger purchase, but also with diminishing returns. Sometimes the trigger pull weight is too light, and the firearm becomes unsafe, or taking off too much material reduces the useful cycle life.

Are these acceptable approaches given HIPERFIRE’s discoveries?

In general, the other approaches attempt to finesse trigger weight with subtle returns. HIPERFIRE has taken the more direct approach and changed the sear’s mechanical advantage for a much more significant reduction in pull weight without sacrificing the hammer’s impact on the firing pin.

HIPERFIRE goes a step further with the EDT, not only do we use the same hammer spring stiffness as the MIL-grade standard, but we also supply a still heavier version with every EDT product. Now, the purchaser can install his trigger with the option of two different lower than MIL weights of 4½ or 5½ lb. pulls. The 5½ lb. pull weight hammer spring makes the hammer hit even harder and lock up still faster than with the 4 ½ lb. pull hammer spring. Find more information on these and other details in follow-on HIPERTECH bulletins.

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We have just addressed the Radical Sear Mechanics (RSM) effect on the EDTs' trigger pull-weight. How does that pertain to the HIPERTOUCH product family, the "weird-looking trigger" first seen by the 50-cal. investor audience in 2011?

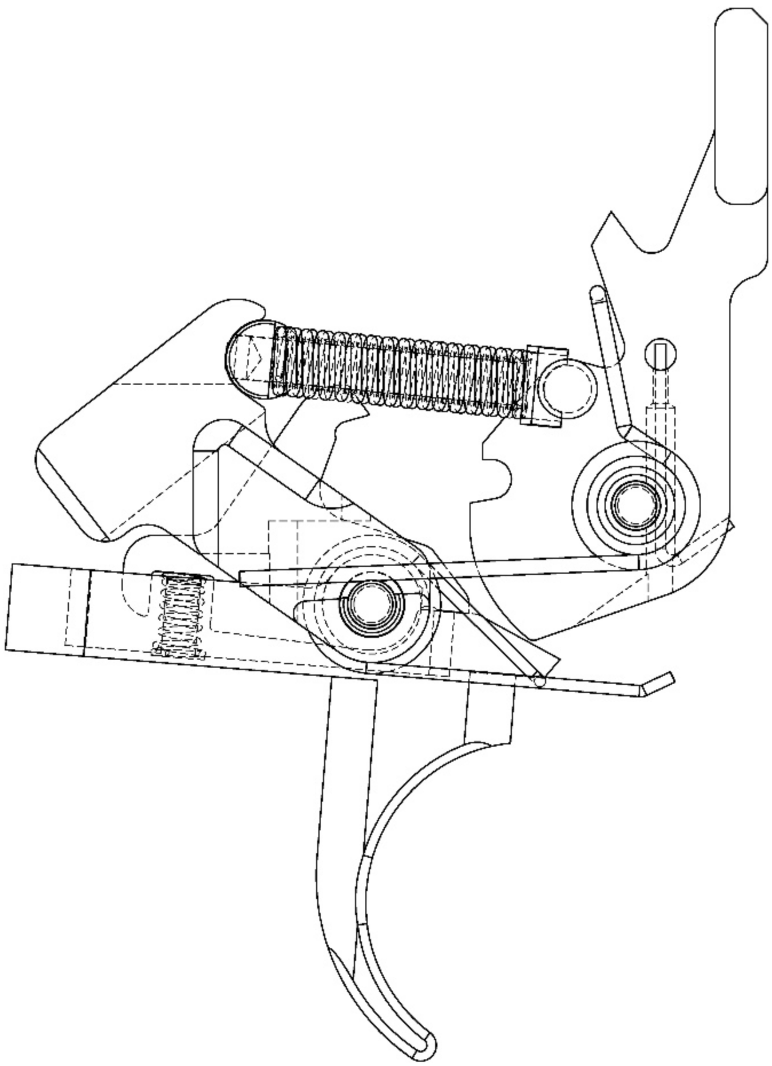

Figure 3. The prototype HIPERFIRE HIPERTOUCH AR trigger showing both pull weight reduction design concepts, the cam-over toggle engine, COTE, and the radical sear mechanics, RSM, with the toggle spring frame.

At first, the Cam-Over Toggle Engine (COTE) applied only to the HIPER-TOUCH line. EDT came later without COTE to provide a higher and safer weight for LE and home defense applications. If you read HIPERTECH #1, recall that the Cam-Over Toggle Engine was already adopted. The investors at that fateful 2011 presentation wanted the "weird-looking trigger" for the AR platform, but the trigger pull-weights were still too high. The need for a still lower weight trigger was the impetus for the RSM development discussed above. What came out of that effort is what is shown in Figure 3 above, the HIPERTOUCH prototype design that included the Cam-Over Toggle Engine (COTE) and the Radical Sear Mechanics (RSM).

The HIPERTOUCH pull-weight was safely reduced to 2½ lbs. by combining the RSM and the COTE concepts. The 50-cal. trigger was now successfully scaled to the needs of the AR15/10 shooter. HIPERFIRE could have gone with still lower pull-weight but was considered unsafe for consumers. However, the weights could be adjusted higher to 3½ lbs. So, every HIPERFIRE trigger product was shipped with extra toggle springs so the shooter could adjust the pull weight to his liking. At EDT product line introduction, weight adjustability was included again by interchanging the hammer springs for 4½ and 5½ lb. pulls.

The receiver-mounted rotation pin (see Figures 3-5 in HIPERTECH #1) for the sliding action of the toggle spring shafts found in the 50-cal. conception was moved to a trigger/toggle frame component (see Figure 3 above) that held the pin. The toggle springs pushed the trigger/toggle frame against the safety selector barrel to stabilize it. So now, any AR lower receiver could accept the trigger without modification.

Conclusion

<u>HIPERFIRE's Radical Sear Mechanics (RSM) approach reduced the trigger pull weight compared to MIL-spec by reducing sear friction</u>. But it also dramatically improved the "feel" and it was very compatible with the Cam-Over Toggle Engine™ (COTE) concept. It retained Eugene Stoner's original, elegant, simple, robust, AR-15, single-stage, trigger implementation. HIPERFIRE has patented these novel improvements in the U.S.

Some manufacturers have adopted a 2-stage configuration that exhibits some positives to reduce pull-weight but at the cost of introducing some negatives. Again, more on this matter in future HIPERTECH bulletins.

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Beyond the feeling, reduced friction also resulted in vastly reduced sear wear. Remember Tribology? Wear is a function of friction. By significantly reducing friction, wear was also greatly reduced. So, everything else being equal except friction, HIPERFIRE triggers have a much longer sear cycle life. We set out to build high-performance triggers for when SHTF. So, HIPERFIRE can build its triggers like tanks, just like the MIL-grade standard, but with reduced pull weight and hard-hitting hammers. See **Appendix A** for comparisons to many quality after-market trigger upgrades.

Look for HIPERTECH white paper #3. There we begin discussing the data that puts these triggers in a league apart.

Appendix A Green Means Column Feature Criteria Satisfied

AR15/AR10 Trigger	Single-Stage	2-Stage	Drop-In Single-Stage	Cam-Over Toggle Engine	Radical Sear Mechanics
HIPERTECH Bulletin				1	2
MIL-SPEC Semi-Auto					
MIL-SPEC Full-Suto					
EDT Sharp Shooter					
EDT Heavy Gunner					
EDT Designated Marksman					
HIPERTOUCH Genesis					
HIPERTOUCH Elite					
HIPERTOUCH Reflex					
HIPERTOUCH Competition					
HIPERTOUCH Eclipse					
A					
B					
C					
D					
E					
F					
G					
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I					
J, Drop-In					
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W					
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