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# Analysis on the Next Generation Assault Rifles and Ammunition Designed for the US Army

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**Abstract**. In recent years, the US Army began actively looking for a replacement for the 5.56 mm M16/M4 assault rifle, which currently is the standard issue weapon for the infantry. The US Army has selected three potential companies to produce the next generation assault weapon. These are the following companies Sig Sauer, General Dynamics, and Textron systems. All companies have submitted prototypes for the next generation assault rifle that are the subject of the analysis in this paper. In addition, the companies also offer new types of ammunition for the abovementioned systems. The purpose of this paper is to compare the three assault rifle prototypes and the ammunition they use to highlight their potential strengths and weaknesses and to address possible reliability problems. Although many of the specifications of the weapons are the subject to company secret, the paper will provide a comparative analysis of small arms samples that plan to replace the 5.56 mm M16/M4 assault rifle, according to available information from various sources.
**Keywords:** small arms, assault rifle, next generation assault rifle

## 1. INTRODUCTION

During the design of small arms, every weapon needs to meet particular requirements that are set by the purchasing party. The US Army's next-generation weapons program aims to find a replacement for the already aging 5.56 mm M16/M4 assault rifle. The new generation of assault weapons must provide significantly better combat properties than the previous assault rifle model. The combat properties of small arms can be divided into four basic categories:
- fire effectiveness,
- weapon manoeuvrability,
- weapon versatility,
- weapon reliability.

Fire effectiveness is the capability of the weapon to inflict damage on equipment and personnel, depriving them of the ability to conduct combat operations or to function in different combat situations. Fire effectiveness is assessed by the losses that the weapon can inflict on the enemy (loss means the damage inflicted on the enemy in personnel and military equipment, which is expressed in numbers, parts or percentages) [1].

Weapon manoeuvrability is a characteristic involving weapon handling and the ability to quickly use the weapon during different combat conditions (weapon dimensions, the use of folding stocks, weapon ambidexterity, different positions of the weapon and the shooter from which firing is conducted, etc.). The manoeuvrability of the weapon is a combination of different weapon features such as the mass and size of the weapon, the mass of the ammunition, the ease of use and time required to operate the weapon, ease of transportation and more. The combination of all these qualities allows the operator of the weapon to operate it with ease, speed and convenience, thus improving the combat effectiveness of the shooter [1].

Weapon versatility characterizes the possibilities for a weapon to be used for more than one way (for automatic fire, hand-to-hand combat, etc.), in different situations (day, night, in conditions of reduced visibility) and for multiple purposes (against personnel, equipment and different types of lightly armoured targets). In order to meet the abovementioned requirements, firearms come equipped with a wide range of accessories including but not limited to bayonets, under barrel grenade launchers, night-day optic sights, rangefinders, tactical flashlights, and more [1].

Weapon reliability is determined by the weapon’s ability to function under different atmospheric conditions on the battlefield, including but not limited to high and low temperatures, high humidity, high levels of obstruction (dust particles) etc. Weapon reliability is characterized by the amount of firearm malfunctions occurring during firing. In modern assault rifles it is not acceptable for the amount of malfunctions to exceed 0.2–0.3 percent [1]. An additional requirement is that firearm malfunctions must be quick and easy to clear.

The next generation assault weapon needs to have increased combat properties like lethality and accuracy. The used ammunition needs to be capable of outperforming even the most modern 5.56 mm and 7.62 mm ammunition. The next generation assault weapon aims to provide significant soldier capability improvements in accuracy, range, and lethality [2].

## 2. ANALISYS ON THE NEXT GENERATION 6.8 mm AMMUNITION

Even before the development of the weapon prototypes started, the US government initiated the Next Generation Squad Weapons program. The modernisation process itself, however, is a part of the strategy set up by the Army Future Command (AFC), which focuses on improving the infantry [3]. The Next Generation Squad Weapons (NGSW) Program is an iterative, prototyping effort, using Middle Tier Acquisition Authority, to develop operationally relevant, squad-level lethality to combat proliferating threats, informed by Soldiers feedback [2]. Government officials had a requirement that the weapon prototypes used the new 6.8 mm ammunition and be designed accordingly to their requirements. In October 2019, the US Army officially selected the 6.8 mm ammunition for use in the new generation of small arms [2]. The ammunition used has significantly better ballistic properties even than the most modern 5.56 mm and 7.62 mm model ammunition [2]. The 6.8 mm round has proven to have higher effective range, higher initial velocity, and high armour penetration capabilities [2].

The main disadvantage of the 5.56 mm calibre ammunition is the fact that the bullet has insufficient mass, which in turn reduces the armour penetration of the ammunition. The problem with the ammunition calibre 7.62 mm, in turn, is the large mass of the bullet compared to the relatively small amount of propellant. The optimal solution for ammunition is somewhere in between the two calibres where the bullet has enough mass for armour penetration while moving fast enough [4]. While a conventional 5.56 mm ammunition creates a barrel pressure at about 310 MPa, a 6.8 mm ammunition creates a barrel pressure in the range of 400 MPa to 550 MPa [4]. As the pressure in the barrel increases, the initial velocity of the bullet is also significantly increased. The high initial velocity improves the ballistic characteristics of the projectile while also increasing the effective firing range, has a positive effect on the shots grouping and armour penetration. The 6.8 mm ammunition is expected to have the ability to pierce the latest generation body armour at a distance of 600 m while maintaining a high level of lethality [4]. This is achieved by the additional propellant charge in the 6.8 mm round casing.

With the high requirements that the weapon must have and powerful ammunition that must be used, the developers face difficult engineering challenges and the need to come up with innovative solutions.

The high pressures are extremely taxing on the alloys used in the weapons and may significantly lower their lifespan. Furthermore, the increased pressure forces, acting on the barrel bore, are likely to make the barrel more subjected to vibration, thus influencing the accuracy of fire.

One of these challenges is to make a barrel that can sustain high pressures for this type of ammunition. Representing one of the main parts of any small arms, the barrel is exposed to particularly harsh conditions - high pressure and temperature created by the combustion of gunpowder gases [5]. The barrel of a gun is designed to withstand the complex forces generated by burning propellant gases that create pressure and emit heat. These forces are not gradual but rather instant increasing the stress on the barrel. Combustion products react chemically with the surface layer of the barrel bore and form new chemical components that weaken the barrel bore thus making it more susceptible to damage. Furthermore, combustion particles act abrasively on the barrel bore and chamber. The combination of all of the abovementioned factors form erosion processes that damage or destroy parts of the barrel bore [6, 7].

Taking into account the extremely high internal barrel pressure caused by the 6.8 mm ammunition, the barrel of these weapons must be able to withstand sufficient elastic resistance against the pressure and temperature of gunpowder gases. In addition, elements such as the chamber and bore will be exposed to extreme loads which necessitates the use of steels and alloys (probably special alloy steels containing chromium, nickel, tungsten molybdenum and vanadium) [5] having high strength, elasticity, and wear resistance. In this next part, the paper will start reviewing the actual prototypes developed by the different companies and the ammunition they present.

## PROTOTYPE DEVELOPED BY “TEXTRON”

Textron presented its prototypes at the conference at the Fort Maneuver Center in September 2019. [8] The company is developing two weapon systems, an assault rifle and an all-purpose machine gun. The developed assault rifle is designated as 6.8 mm Textron NGSW-R [9]. The prototype of a new generation assault rifle, developed by the company "Textron" is presented in Fig. 1.

Fig. 1. Overview of the next generation assault rifle prototype developed by “Textron” [9]

The weapon fires a bullet with a calibre of 6.8 mm that is believed to weigh 8.8 grams, reaching muzzle velocities of about 915 m/s or even higher ones [9]. The company also provides some weapon characteristics: the weapon is multi-calibre reconfigurable between 6.5 mm and 7.62 mm, closed bolt, forward feed, gas piston operated, weighing 3.7 kg. [10]. Textron is still competing with both General Dynamics and Sig Sauer for the contract to build the Next Generation Squad Weapon (NSGW). All three companies won awards to build prototypes for troops to test, starting in spring of 2010 and continuing through late 2021. No follow-on production contract is guaranteed [12].

In addition, the company is also developing its own design of the 6.8 mm ammunition. The company has also developed new types of ammunition using its own technology in calibres 5.56 mm, 7.62 mm, 6.5 mm, and 6.8 mm for the prototype Fig. 2. Telescoped rounds feature a bullet completely encased in a polymer shell, like a shotgun, with gunpowder surrounding the bullet in the shell [11]. A similar ammunition design has been used in other weapon systems such as the 4.73 mm German Heckler & Koch G11 assault rifle. The designed ammunition is a product of the Dynamit Nobel company [13].


Fig. 2. Cased telescopic ammunition in different calibres developed by Textron compared to the classic NATO cartridge case ammunition on the left [11]

The main purpose of this type of ammunition is to reduce the weight and dimensions of the ammunition without a significant change in its characteristics. The company claims that their ammunition design provides 35% overall cartridge weight reduction versus equivalent, conventional brass [10]. The polymer, from which this ammunition is made, is the subject to company secrecy and information about it is extremely limited. Despite the fact that the information about the ammunition is limited, certain questions arise about its functionality. It is uncertain if the ammunition will be able to meet the necessary requirements to be adopted for service.

The main ammunition requirements are:

- Strength requirement - this type of ammunition can be weaker (be able to withstand less pressure) that a conventional cartridge due to the fact that its outer shell is made out of polymer and not metal as in the classic type of ammunition. Strength is extremely important because the outer shell of the ammunition is the subject to high-pressure forces created by the expansion of propellant gases when firing. In case of insufficient casing strength, the ammunition can rupture and potentially damage the weapon and the operator. The extraction of a ruptured shell casing is often a time consuming process leaving the operator with a malfunctioning weapon and making him vulnerable. Additionally, if the ammunition casing is not strong enough, it can easily be damaged during handling or transportation. The use of a polymer casing may require careful handling and the use of additional care while operating and loading into a magazine.
- Temperature resistance requirements - ammunition temperature resistance is extremely important. Nitroglycerine, one of the main components of gunpowder, ignites at a relatively low temperature around 170°C. One of the functions of the metal shell casing is to capture and isolate a part of this temperature from the chamber. Once the cartridge case is extracted from the chamber, it carries with it a certain amount of heat generated from the combustion of the gunpowder. If the shell casing melts in the chamber, it can cause the weapon to malfunction. The polymer shell casing must be made of a type of polymer that can withstand high temperatures, does not melt and has sufficient insulating properties, thus preventing the nitroglycerine from ignition at high temperatures a phenomenon known as thermally induced firing. Polymers usually have very good insulating properties and low thermal conductivity, which makes them a good material for insulating heat from the chamber.
- Pressure sealing- another main function of the cartridge case is to seal the back of the barrel when firing. When a shot is fired the pressure in the barrel rises rapidly, which subjects the cartridge case to elastic deformation. Thanks to the pressure forces, the cartridge expands thus sealing the chamber and preventing the leakage of gases. The design of the polymer cartridge case must be made in such a way as to allow the gases to be securely kept inside the barrel when fired, or the weapon system must be redesigned in such a way as to prevent gunpowder gases from escaping during firing. A similar problem was observed in the 15.4 mm Drece needle rifle and the 11 mm French Chaispot rifle, in which the problem of gas leaks from the chamber was solved by adding a rubber seal to the weapon [14]. The limit of elastic deformation of the polymer is larger, which allows the gap between the barrel and the cartridge to be greater. In theory, a polymer made shell casing should possess a higher plastic deformation margin thus making it better in sealing chamber gasses.

OPERATION PRICIPLE OF THE 6.8 mm NGSW-R ASSAULT RIFLE PROTOTYPE DEVELOPED BY "TEXTRON"

Although Textron does not reveal details about how their weapon prototype functions, the fire rate or the length of the barrel, certain parts and mechanisms of the system can be identified by examining a theoretical 3D model of the prototype. With the help of the model, assumptions can also be made about the principle of operation of the system.

After the parts and mechanisms are identified according to Fig. 3 and with the above-mentioned in the paper, the following can be determined: According to the number of personnel operating the weapon, the weapon is individual.

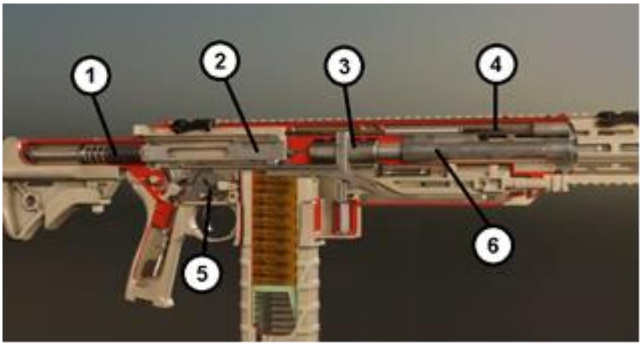


Fig. 3. 3D model of the possible design of the 6.8 mm NGSW-R assault rifle prototype made by "Textron" [15]. 1 – two-component recoil mechanism with a buffer device; 2 - bolt carrier group; 3 - chamber; 4 - spring loaded piston; 5 - trigger mechanism; 6 – barrel.

It is of a medium calibre using an intermediate round. According to the design features of the inner surface of the barrel bore the weapon has a rifled bore. Due to the presence of a gas piston, it can be determined that the system is gas operated [1], and the presence of a spring on the gas piston indicates that it is a short stroke gas operated system. As an additional source, an animated in 3D environment featuring the cycles of the weapon is summarised in Fig. 4. The chamber is made as a separate part from the barrel. The trigger mechanism is spring loaded with a hammer, with a firing pin made as a separate part, located in the bolt.

The extraction mechanism is a type that uses the next round as a mean to extract and eject the previous round. The weapon is magazine fed with a two-roll magazine holding approximately 20 rounds.

The action of the experimental assault rifle is as follows: after pulling the changing handle, the bolt together with the bolt carrier reach the rear end position while being guided by the guide rails. Simultaneously, the bolt carrier group compresses the return spring. With its rear section, the bolt carrier pushes the hammer of the trigger mechanism, in turn the hammer is rotated and engaged with the hook of the trigger.

Following its rails, the chamber sinks down and compresses its spring. A push lever removes the spent cartridge from the chamber and feeds a fresh one from the magazine. When the reload lever is released, which currently is in the rear end position, the accumulated energy in the return spring moves the bolt carrier group forward. Under the action of the guide rails, which are connected to the chamber, the chamber moves in the upper position coaxial with the position of the barrel. The weapon is loaded. When the trigger is pressed, the hammer is released from the tooth of the trigger. The hammer then rotates forward and strikes the firing pin, which in turn strikes the primer in the cartridge. A shot is fired, some of the gunpowder gases pass through the gas port on the barrel and push the bolt carrier piston.


Fig. 4. Operation sequence of the 6.8 mm NGSW-R assault rifle prototype [15]
1 - Hammer, 2 - Extraction of the spent shell casing forward and to the side trough an opening in the lower front part of the weapon, 3 - Guide rails, 4 - Barrel springs

The piston rod then strikes the front upper part of the bolt carrier and gives off the energy it has accumulated. The bolt carrier, together with the bolt, start moving backwards while compressing the return spring mechanism and actuating the buffer device in the buttstock. The bolt carrier group rotates the hammer and again engages it with the trigger tooth. The guide rails, connected to the bolt carrier, move the chamber to the lower position and compress its spring. Under the action of the energy, accumulated in the return spring, the bolt carrier group begins starts moving forward. A specially designed lever pulls the next cartridge from the magazine and inserts it into the barrel. With its front part, the newly extracted cartridge pushes the spent cartridge case out of the chamber which then is ejected out of the weapon by a spring. The abovementioned process is then repeated until there are no more rounds left in the magazine or the trigger is released.

The company "Textron" has created a system that in structure and principle of operation differs significantly from any other assault rifle and is quite different from the classic assault rifle layout used in assault rifles such as the 5.56 mm M16/M4. At the current stage, information from tests of the system by the US Army is not available.

High degree of complexity and high number of moving parts of the system would probably complicate its operation and possibly decrease the reliability factor. The introduction of additional moving parts, namely by the moving chamber, could reduce the rate of fire. Furthermore, the process of removing a jammed round in the chamber is made difficult by the necessity to remove the magazine of the weapon first, complicating the process and making it more time consuming. The ammunition used by the weapon is experimental and may not function reliably. Further test and research needs to be carried out in order to truthfully conclude and evaluate the performance of both, the weapon and the round. Due to the lack of sufficient information, the analysis of this system is not conclusive and may be a subject for debate. There is also the possibility that the prototype will be modified in the future.

ASSAULT RIFLE RM277 - 6.8 mm. PROTOTYPE MADE BY "GENERAL DYNAMICS"

The 6.8 mm GD RM277 assault rifle is being developed by a consortium of companies, led by American industrial giant General Dynamics for the NGSW-R “Next Generation Squad Weapon – Rifle” program, funded by US Army. Besides GD, which acts as a system integrator and a project leader, consortium also includes Beretta USA, which is responsible for the weapon itself, and True Velocity, which is responsible for new ammunition [16]. At present, the company has provided very little information about their development. The General Dynamics assault rifle (Fig. 5) is named RM277 - 6.8 mm [17]. Unlike the prototype of the companies "Textron" and "Sig Sauer", the prototype of the company "General Dynamics" is developed according to the layout where the magazine is located behind the trigger mechanism also known as the "Bull Pup" design.

Fig. 5. Overview of the assault rifle prototype developed by „General Dynamics“[8]

According to General Dynamics, the weapon is described as “gas and recoil operated, impulse averaged, air cooled ’system” [17]. The General Dynamics assault rifle operates by combining two operating principles being gas and recoil operated at the same time, thus, incorporating a gas piston, a gas port, and a recoiling barrel. The barrel is air-cooled, the ammunition is fed from a magazine with a capacity between 20 and 30 rounds. The weapon also comes equipped with a sound suppressor attached to the front end of the barrel [17]. The introduction of a sound suppressor in the system reduces the acoustic intensity of the muzzle when a shot is fired. Furthermore, the additional weight added to the front of the barrel acts as a counterweight negating the oscillations occurring while firing thus, improving accuracy and shot grouping [18]. According to the company, the sound suppressor will have the same lifetime as that of the barrel [17], i.e., it will function reliably together with the barrel for the same number of shots. This raises the question of the quality of the sound suppressor and the need for it to be made of high quality materials, which could increase the cost of the system.

Based on the conducted analysis, it is believed that the lower receiver of the weapon is made of metal alloy. The assault rifle is ambidextrous and is suitable for firing by both right and left-handed operators, the reloading handle can be operated from both the left and right side of the weapon [19]. In Fig. 4, the cartridge ejection port is located on the right, but probably the ejection mechanism will have the function to be changed depending on the requirements of the operator, i.e., for shooting with the left or right hand. In the upper receiver, the weapon is equipped with STANAG 4694 "NATO Accessory Rail", which allows for modularity and the attachment of additional accessories. The charging handle is located in the upper front part of the weapon. According to the company, the weapon is optimised for minimal recoil when firing and, at the same time, for high accuracy and low weight [17].

Innovation of this system is the use of both, the energy from the propellant gases and the recoil of the barrel for the automation of the weapon’s action. The advantages of this mixed system approach is that when a system with a short stroke of the barrel has a combination of late opening of the barrel making for an easy cartridge extraction while maintaining high rates of fire, thus allowing for high reliability of the weapon system. Another advantage is the relatively small force transmitted from the rifle to the operator (shooter's arm) when firing without the use of special shock absorbers [1] thus improving weapon handling. The use of a gas-operated system in the weapon is probably made to ensure that the barrel has enough force to travel to the rear dead position and to compress the recoil spring acting as an acceleration mechanism. By utilising both of these systems, the barrel can be made lighter so that, the weight of the assault rifle is significantly reduced.

Potential shortcomings of this weapon system can be identified: complication of the weapon's action by the introduction of an accelerator mechanism. Further complication of the weapon system is due to the presence of two principles on which the weapon is automated. The presence and movement of large parts and masses at the time of firing, which leads to a shift in the centre of gravity of the weapon and stability while firing. Large masses and speeds lead to high impact loads on the parts, which shortens their life and requires the installation of shock and buffer springs. The movable barrel places restrictions on the use of detachable muzzle devices (silencers, compensators, etc.), as they change the mass of the barrel, especially for light barrels [1].

The prototype assault rifle is a bullpup firearm. In a bullpup firearm, the bolt carrier group and the bolt are placed behind the trigger mechanism. This type of design has several advantages over the conventional one. This design allows for the production of a shorter weapon compared to a carbine with the same barrel length, which significantly improves the manoeuvrability and handling of the weapon. The advantages of the longer barrel, such as improved accuracy and higher round initial velocity are preserved, while at the same time maintaining a compact weapon design. Nevertheless, the bullpup design has some limitations. The face of the shooter is close to the action and it is subjected to loud noise and pressure. Because the trigger is moved forward, it is necessary to use a lever system, which makes the trigger system with lower sensitivity [20], i.e., this type of a trigger mechanism has worse characteristics than a conventional one.

## 6.8 mm POLYMER CASED AMMUNITION

The 6.8 mm RM277 system uses a composite cartridge case developed by the company True Velocity shown in Fig. 6. From the very name of the ammo "composite" means that it is made of two or more materials with different physical or chemical properties [21].

Fig. 6. 6.8 mm polymer cased round [22]

The cartridge consists of a metal base, on which the polymer body is cast [22], with dimensions identical to a conventional ammunition. Exceptions are the front end of the cartridge case and the area in which the primer is held.

Figure 6 shows that the front end of the cartridge case is made shorter and narrower. From the above-mentioned, the following conclusions can be made: the barrel of the weapon is precisely designed in a non-standard way to use the composite cartridge case - the shape and design of the barrel is governed by the shape and size of the cartridge case [5].

The elimination of the cone (slope) of the cartridge is due to the fact that this is one of the most vulnerable parts of the round. When choosing a polymeric material for the cartridge case body, that does not meet the strength characteristics of a metal sleeve, this modification eliminates potential weak spots and ensures reliability. Potential problem with the composite cartridge case is the strength requirement. The body of the cartridge case is subjected to high forces of heat, friction, and pressure and must be strong enough to withstand such forces. One of the technical solutions to counteract this issue is to make channels in the chamber that lower the forces of friction during extraction. It would be extremely interesting to understand the design of the chamber once more data is available [5] and to see what kind of solution is chosen to counteract this potential problem.

The potential advantages of using this type of round are the following: the polymer used in the cartridge case can be significantly lighter than a metal one. The polymer is significantly cheaper to manufacture and has much better insulating properties than metal [23]. The polymer is also corrosion resistant which means that the ammunition can be stored for a much longer time. Due to the lack of sufficient information, the analysis of this system is not conclusive and may be a subject for debate. There is also the possibility that the prototype will be modified in the future.

## ASSAULT RIFLE 6.8 mm „MCX SPEAR“– DEVELOPED BY „SIG SAUER“

The company "SIG Sauer" is the third company to develop its prototype for the next generation weapon program. The prototype named "MCX Spear – 6.8 mm" is showcased in Fig. 7.

Fig.7. Overview of the assault rifle 6.8 mm "MCX Spear" developed by „SIG Sauer“ [24]

Of the three companies, SIG Sauer adopts the most conservative approach, as their prototype assault rifle is based on the 5.56 mm SIG MCX [24, 25] assault rifle also developed by the same company, which is similar in operation to the 5.56 mm M16 / M4 assault rifle but with considerable improvements. It is most probable that the weapon and weapon components are modified in order to fire the more powerful round while the main working principles of an M4 family weapon remain the same.

The 6.8 mm MCX Spear assault rifle works on the principle of using the pressurized gas from the cartridge. The assault rifle is gas operated with a short stroke of the piston [24]. The system has a non-automatic gas regulator with two settings [24]. The barrel is locked by a rotating bolt as with all other weapons from the M4 family. The main difference of the system from the 5.56 mm M16 assault rifle is the position of the recoil mechanism. While in the 5.56 mm M16 assault rifle family the main part of the recoil mechanism is located in the buttstock [26] As seen in Fig. 8 showcasing the entire internals of a short-barrel M4 family 5.56 mm carbine rifle [27]. In the design of the 6.8 mm MCX Spear, the recoil mechanism is placed above in the upper receiver Fig. 9 [24]. This is a great advantage due to the fact that the weapon can have a folding stock, while in systems such as the 5.56 mm M16 this is impossible because the recoil mechanism is located in the buttstock, hence it cannot be folded but rather only adjusted according to the shooter's needs [28].

Fig. 8. Section of view of the 5.56 mm M16A1 assault rifle, the section clearly shows that the recoil mechanism is located in the stock [27]

This significantly improves the manoeuvrability of the system by making it suitable for crews and Special Forces that require a more compact weapon. Another significant difference here is the use of a short-stroke piston system rather than a direct impingement system, which improves weapon reliability.

In order to reduce the recoil, caused by the use of a more powerful ammunition, a special buffer device marked with the letter "B" in Fig. 9 has been implemented.

During firing, the barrel, together with the bolt carrier group moves to the rear end position in the lower receiver where it gives out inertia energy to the buffer device absorbing some of the recoil forces [24]. The weapon is magazine fed with a probable magazine capacity varying between 20 and 30 rounds. In addition, a sound suppressor comes issued with the weapon also developed by SIG Sauer [24].

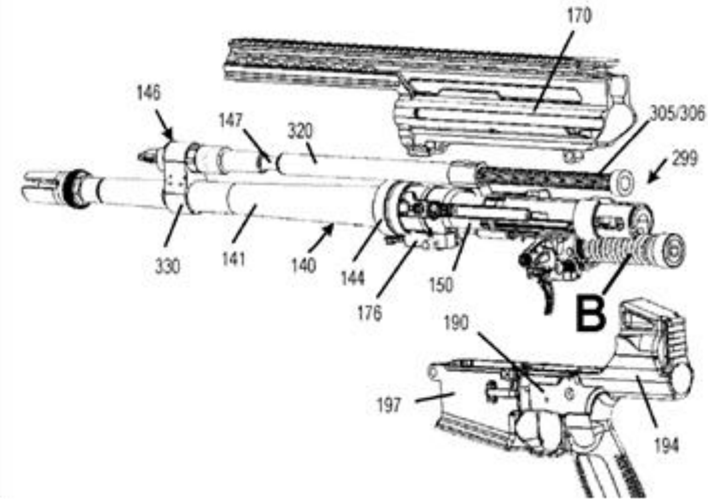


Fig. 9. Diagram showing the location of the parts and mechanisms of the assault rifle 5.56 mm SIG MCX, with the recoil mechanism located at the position 305/306 [24]

Firing controls are generally similar to the 5.56 mm M16 rifle/M4 carbine, although SIG Sauer NGSW-R 6.8 mm MCX Spear prototype features additional non-reciprocating folding charging handle on the left of the receiver, besides “5.56 mm M16 standard” T-shaped handle at the rear. All sights are installed using integrated STANAG 4694 "NATO Accessory Rail" located on the top of receiver and forward part of the weapon [24].

BRASS-STEEL HYBRID AMMUNITION

The weapon system uses a 6.8 mm ammunition with a composite hybrid cartridge shown in Fig. 10. The cartridge appears to be designed to resist extremely high pressure. The shell casing consists of three components: a steel base - 1, a brass body - 2, and a body that connects the components together - 3 [26]. This design was probably chosen to achieve greater resistance of the shell casing caused by high pressure of the system. The fact that the shell casing is a composite would cause a certain increase in cost in its manufacturing due to the complicated technology and the use of several types of materials.

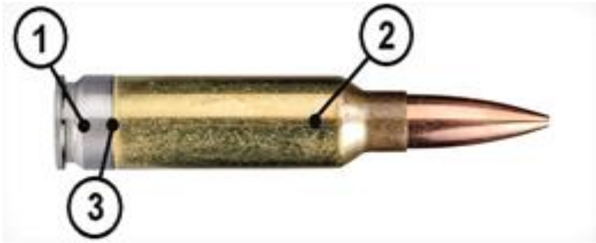


Fig. 10. 6.8 mm hybrid ammunition, 1-steel base, 2-brass body, 3-connecting body

The base of the ammunition is most probably made out of steel in order for the shell casing to withstand the high forces of friction while the round is being extracted from the chamber during high-pressure conditions. Thus, the round is capable to function reliably under severe pressure without breaking apart. An identifiable problem can also be the weight of the ammo, since metals are heavier then plastics increasing the overall weight of the carried ammo. Due to the lack of sufficient information, the analysis of this system is not conclusive and may be a subject for debate. There is also the possibility that the prototype will be modified in the future.

## CONCLUSIONS

The following table summarizes the main characteristics of all three-assault rifle prototypes. The main characteristics of each assault rifle is presented in Table 1.

Table 1. Weapon and ammunition characteristics

| Assault rifle prototype by | Ammunition | Operation principle | Design |
|---|---|---|---|
| By “Sig Sauer:  |  6.8 mm Brass-steel hybrid ammunition | Gas operated with a short stroke gas piston | Conventio nal |
| By “General Dynamics:  |  6.8 mm polymer cased ammunition | Gas and recoil operated, impulse averaged | Bullpup |
| By “Textron systems:  |  6.8 mm cased telescopic polymer ammunition | Gas operated with a moving chamber | Conventio nal |

For the prototype assault rifle and ammunition developed by “Textron”: the possible pros of the system are the innovative design, ambidextrous weapon, the reduction of weight with the use of the polymer cased telescopic ammunition. Possible issues of the system may be with the introduction of an untested ammunition design. Other possible concerns are the moving chamber, which brings up the issue of gases escaping from the gap between the chamber and the barrel. Furthermore, the movement of the chamber and the parts that drive it may affect the fire rate due to the fact that it will take more time to complete a whole firing cycle.

For the prototype assault rifle and ammunition developed by “General Dynamics”: bullpup design incorporating a long barrel while maintaining a compact weapon. Ambidextrous weapon gas and recoil operated. Possible issues may occur with the presence of two automating systems, more moving parts than in a conventional system. Use of polymer ammunition reducing weight and costs. Possible issues with ammunition pressure resistance and rigidness.

For the “Sig Sauer”: assault rifle prototype: the most conventional design using an already proven system. The weapon system is redesigned for a more powerful round. The round used is a Brass-steel hybrid raising possible questions about round complexity and manufacturing capabilities. The weapon is based on an already familiar system making training of personal easier.

The above-mentioned analysis is not conclusive and completely theoretical, more data and research needs to be conducted in order to exactly determine all weapon capabilities. The paper highlights possible interesting engineering solutions and weapon principle of operations.

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