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Risk Assessment & ALARP Justification (Individual Written Report)

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Abstract

This report presents a comprehensive hazard identification analysis of the AK-47, focusing on the assessment and mitigation of four primary hazards associated with its use. Each hazard has been assigned to specific team members for in-depth research and analysis, facilitating a collaborative approach to risk management. Central to this investigation is the principle of ALARP (As Low As Reasonably Practicable), which aims to minimize risks to acceptable levels while considering practical limitations.

Among the identified hazards, the recoil produced by the AK-47 poses significant challenges to user safety and weapon control. To address this concern, the report proposes the installation of a muzzle brake as the preferred method for recoil reduction. This solution is analysed through a Cost-Benefit Analysis (CBA), evaluating various recoil mitigation strategies, including muzzle brakes, gas systems, and ergonomic designs. The CBA considers not only the financial implications of each solution but also their potential contributions to safety enhancements and overall performance improvements.

The findings of this report demonstrate that implementing a muzzle brake effectively reduces recoil to an ALARP level, striking a balance between cost efficiency and safety enhancement. By examining the practicalities and benefits of this approach, the report underscores the importance of informed decision-making in the design and modification of firearms to ensure optimal user safety and operational effectiveness.

Abbreviations

ALARP	As Low As Reasonably Practicable
AK47	Avtomat Kalashnikova (Russian for “automatic Kalashnikov”)
CBA	Cost-Benefit Analysis
HAZID	Hazard Identification
RCM	Risk Control Matrix
SSW	Safe System of Work
PPE	Personal Protective Equipment

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1. Introduction

Risk assessment is a crucial management tool that plays a vital role in ensuring the safety and health of workers and the general public. Many individuals may not realise that conducting risk assessments is not just beneficial but also a legal obligation for employers and certain self-employed individuals. An accident is an unplanned event that leads to loss, while a hazard is defined as a potential source of harm. In contrast, risk refers to the probability and severity of negative outcomes, such as injuries or damages, that arise from these hazards.

This report centres on the AK-47, a Soviet-designed automatic assault rifle that stands out as one of the most prevalent shoulder firearms globally. The term "AK" is derived from *Avtomat Kalashnikova*, in honour of its designer, Mikhail Timofeyevich Kalashnikov, who introduced the weapon in 1947. Since its formal adoption by the Soviet military in 1949, the AK-47 has garnered recognition for its operational simplicity, durability, and reliability in challenging conditions, facilitating its mass production [1].



Figure 1 - AK-47

The AK-47 is built around a 7.62-mm cartridge, achieving a muzzle velocity of about 700 meters per second. It has a cyclic firing rate of 600 rounds per minute and can function in both semi-automatic and automatic modes. Designed to accommodate a curved magazine holding 30 rounds, it employs a gas-return tube mechanism that allows for efficient ejection of spent cartridges. Despite its numerous advantages, the AK-47 has faced scrutiny regarding its accuracy due to recoil forces generated by the powerful 7.62-mm round and the internal blowback forces of its heavy mechanisms.

The purpose of this report is to perform an in-depth hazard identification and risk assessment of the AK-47, examining the various hazards and risks associated with its lifecycle, from production to target disposal. By critically assessing the principles of Safety Led Design, this analysis will highlight the importance of incorporating safety considerations throughout the design and operational phases of firearms.

Each identified hazard will be thoroughly documented, including detailed descriptions, pre-control risk estimates, and suggested controls and mitigations aimed at achieving an As Low As Reasonably Practicable (ALARP) status. Furthermore, the report will demonstrate an awareness of the relevant regulations that govern the manufacture, storage, transportation, and use of explosives, ensuring adherence to legal standards and promoting industry best practices.

By effectively communicating the results to both technical and non-technical audiences, this report aims to enhance understanding of the safety challenges linked to the AK-47 and provide a foundation for future assessments and improvements in firearm safety design and protocols.

2. Risk Assessment

A risk assessment is an integral part of a Safe System of Work (SSW) (Safe Persons; Safe Equipment; Safe Place; Safe Practice) and uses a systematic approach to identify, evaluate, and control risks in any environment to ensure safety and minimise harm in accordance with the Management of Health and Safety at Work Regulations 1999. It involves an examination of identified hazards, followed by either a qualitative or quantitative estimation of the risks associated with those hazards. It also includes notifying the business and relevant personnel of the potential hazards present during work activities and the measures in place to mitigate these risks. Furthermore, it serves as a demonstration that the business is actively managing safety and financially supporting it by reducing the identified risks to a level deemed As Low As Reasonably Practicable (ALARP) [2] [3].

2.1 Hazard Identification

Def Stan 00-056, Part 1, Issue 7 defines a hazard as the potential to cause harm. The Hazard Identification (HazID) process is a systematic approach used to identify and evaluate these potential hazards associated with a system, process, or activity, serving as a critical component of risk management and safety assessments. In the context of the AK-47, this process involved collating relevant hazards through collaborative brainstorming sessions among team members, where each individual contributed insights based on their expertise and research. Various techniques, including checklists and reference materials, were utilised to ensure a comprehensive review of hazards associated with the manufacture, storage, transportation, and use of the firearm. The identified hazards were then systematically documented, covering aspects such as mechanical failure, user handling, and environmental factors, thus creating a solid foundation for subsequent risk mitigation analysis [4].

	Hazard	Description
Operational	Unintentional discharge/ Inadvertent Firing	Trigger being pulled accidentally, causing injury or death.
	Failure to fire	A round fails to fire, possibly leading to dangerous actions by the operator.
	Misfire	A delayed discharge can cause the weapon to fire when it is thought to be safe.
	Double feed or jam	When more than one round enters the chamber, potentially causing the weapon to malfunction.
	Overheating during extended firing	During extended firing sessions, the barrel and internal components could overheat, causing burns or malfunctions.
	Ricochet of bullets	Bullets hitting hard surfaces at angles, potentially causing injury to the operator or others nearby.
	Magazine defects leading to misfeeds	Malfunctioning magazines can lead to misfeeds or improper chambering of rounds.
	Slamfire (firing as the bolt closes)	When the gun fires as soon as the bolt closes without pulling the trigger, usually due to a malfunction.
	Weapon cycling malfunctions	This could occur when the gas piston system malfunctions, causing jams or unpredictable firing.
Handling	Improper safety use	Failure to engage the safety switch when not in active use could lead to accidental discharge.
	Lack of trigger discipline	Having a finger on the trigger when not ready to fire may result in accidental firing.
	Wrong ammunition type	Loading incorrect ammunition into the AK-47 can cause catastrophic failures.

	Barrel obstruction	If debris or foreign objects obstruct the barrel, firing could result in an explosion or severe damage to the gun and operator.
	Inadequate gun cleaning and maintenance	Leads to malfunctions and safety risks, including misfires or jams.
Environmental	Extreme temperatures	Cold or hot weather may affect the performance of the AK-47, leading to malfunctions or reduced accuracy.
	Wet or humid conditions	Water exposure can cause rusting or malfunction of the weapon's components.
	Dust or debris	Sand or dirt entering the weapon's mechanism could cause it to jam or malfunction, especially in combat environments.
	Concealed locations	Firing in confined or poorly ventilated spaces can cause harmful exposure to gases and noise.
	Proximity to flammable materials	The muzzle flash or heat from the weapon could ignite nearby flammable materials.
Storage / Transportation	Improper Storage	Not securing the weapon properly can lead to accidental access by unauthorised persons (children, untrained individuals).
	Corrosion	Poor storage conditions can lead to rust, especially on metal components, leading to weapon malfunction.
	Unauthorised Access	Stolen or unsecured AK-47s can be used for illegal or harmful purposes.
	Trigger Locks	Failure to use trigger locks can lead to accidental discharge during transport or storage.
Health & Safety	Recoil Injury	Improper holding or control of the AK-47 can cause the recoil to injure the shooter's shoulder, face, or hands.
	Hearing damage	The loud report of the AK-47 can cause hearing loss or damage without proper ear protection.
	Eye damage	Ejected shell casings or debris can strike the eyes, causing injury if eye protection is not used.
	Burn injuries	The barrel and gas tube can become very hot after firing, leading to burns if touched.
	Ergonomic issues	Poor posture or handling techniques could lead to muscle strains or long-term injury.
Human Factors	Training deficiencies	Lack of proper training in weapon operation could result in accidents.
	Stress-induced errors	In high-stress environments, individuals may improperly handle or use the AK-47.
	Impairment	Operating the AK-47 while under the influence of alcohol, drugs, or while fatigued could lead to poor judgment and accidents.
	Negligence in firearms safety	Not adhering to basic firearm safety principles (e.g., muzzle awareness, keeping the finger off the trigger) can result in serious accidents.
Malicious	Intentional misuse	The AK-47 could be used in criminal activities or acts of violence.
	Insider threats	Someone within a controlled environment misusing the weapon for harm.

2.2 Hazard Descriptions

The following functional and physical hazards have been extracted from the HAZID stage and are the four most crucial hazards:

Recoil - The force generated when the AK-47 is fired can cause injury, especially if the firearm is not held properly. Recoil may result in shoulder, face, or hand injuries.

Ejected Casings / Eye Damage - When rounds are fired, spent casings are ejected from the weapon at high speed. These casings can cause injury if they strike the operator or others nearby, especially in close-quarters or confined spaces.

Misfire - A round that fails to discharge after the trigger is pulled, potentially causing dangerous situations if the firearm is not handled properly, leading to improper clearing or unintended firing later.

Inadvertent Firing - Accidental discharge of the weapon due to mishandling, mechanical failure, or improper engagement of the safety mechanism, potentially leading to injury or death.

Following the Hazard Identification (HazID) phase, the team comprises four members, each tasked with a specific hazard for further risk mitigation analysis. This report will specifically focus on the recoil hazard.

2.3 Understanding Recoil

Recoil is defined as the sudden backward movement that a gun makes when it is fired. That sudden backward movement is a result of momentum conservation. Newton's third law states "every action has an equal and opposite reaction". If object A acts a force upon object B, then object B will exert an opposite yet equal force upon object A [5].



Figure 2 - Newtons Third Law illustration with AK-47

The physics behind all "guns" remain the same (e.g. cannons, shotguns rifles) as they work on the basic idea of conservation of momentum and the change in energy from potential to kinetic. When the AK47 is fired, the firing pin strikes the primer contained in the ammunition, igniting the gunpowder, causing a relatively small explosion. The burning powder produces gas which rapidly expands in the cartridge and pushes the projectile(s) out of the cartridge and down the barrel. This process happens in a split second and generates an enormous amount of force. According to Newton, the projectile's forward momentum must be balanced out by an equal and opposite reaction, which is the rearward thrust of recoil [5].

Momentum characterises an object's resistance to change in motion. If this is motion along a straight line, we call it linear momentum; if it is rotational motion, we call it angular momentum. The basic idea is the same: moving things like to keep moving, and to change their motion we must apply a force. If no force is present, then the momentum doesn't change, i.e. it is conserved.

2.4 Pre-Control Risk Estimate

This image depicts a Risk Control Matrix (also called a Risk Assessment Matrix), which helps assess and categorise the risk of potential hazards based on two parameters.

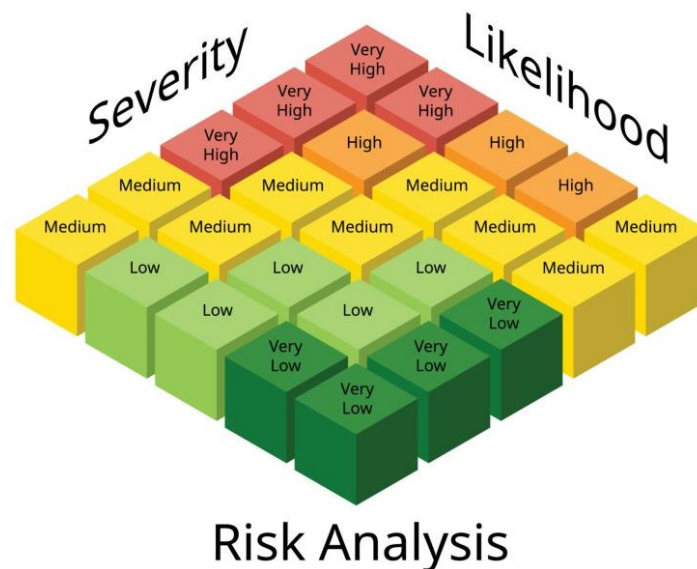


Figure 3 - Illustration of Risk Control Matrix

The AK-47 was assigned a risk factor of 9, categorising it as a medium risk:

Unique ID	Likelihood Rating	Severity Rating	Risk Factor	Risk Class
AK47-01	Occasional (3)	Significant (3)	9	Medium

Figure 4 – AK-47 Risk Class Table

2.4.1 Likelihood

Likelihood is defined as a measure of the probability that an accident will occur and is rated from:

Likelihood Rating	Description of Likelihood	Estimated Frequency Range
Frequent (5)	High chance of occurring	1-100 instances
Likely (4)	Moderate chance of occurring	100-1,000 instances
Occasional (3)	Somewhat rare but possible	1,000-10,000 instances
Unlikely (2)	Rare event, but still plausible	10,000-100,000 instances
Improbable (1)	Extremely unlikely, but not impossible	100,000-1,000,000 instances

The likelihood rating for the AK-47 recoil is 3

2.4.2 Severity

Severity is defined as a measure of the degree of harm and is rated as:

Severity Rating	Description of Severity
Negligible (1)	No injury or minimal consequence
Minor (2)	Minor injury or damage
Significant (3)	Major injury or moderate impact
Major (4)	Severe injury or one death
Severe (5)	Multiple deaths or catastrophic consequences

The severity for the AK47 recoil is classed as **3** (Major injury or moderate impact).

2.4.3 Tolerability Band

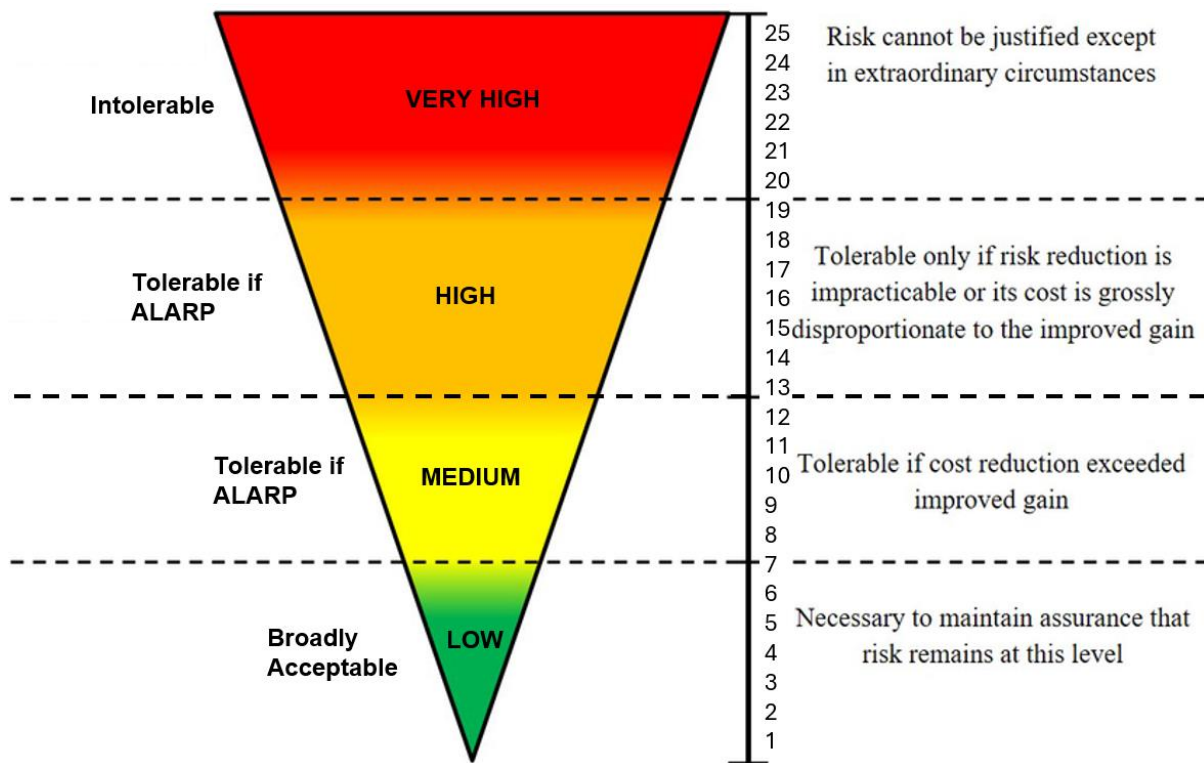


Figure 5 - Risk Tolerability Triangle for AK-47

This diagram represents a Risk Tolerability Triangle, also known as a “Carrot Diagram”, inspired by the ALARP principle, which is a widely used, useful tool, in risk management. The inverted triangle illustrates how risk levels are categorised from acceptable to intolerable based on the likelihood and severity of potential hazards. The ALARP concept implies that risk must be reduced to a level that is as low as is reasonably practicable, meaning any further risk reduction would involve a disproportionate cost compared to the safety benefit [7].

For AK-47 operations, this diagram can help prioritise risk management actions. For example, misfire or inadvertent firing may be classified in the high-risk category (14-20), requiring significant mitigation like regular maintenance or strict safety protocols. On the other hand, recoil might fall in the medium-risk range, necessitating weapon attachments or user training to minimise harm but not drastic risk-elimination measures.

2.4.4 Risk Control Matrix

For the AK-47, risks must be plotted on the project's Risk Control Matrix (RCM) based on their likelihood and severity to provide an estimate of the risk level. This estimation helps prioritise actions and guide more detailed assessments. The matrix offers a broad indication of risk significance, with the most critical risks warranting further analysis. Typically, these include potential accidents with severe outcomes, such as multiple fatalities.

		Severity			
		Catastrophic (4)	Critical (3)	Marginal (2)	Negligible (1)
Likelihood	Frequent (6)	A (24)	A (18)	A (12)	B (6)
	Probable (5)	A (20)	A (15)	B (10)	C (5)
	Occasional (4)	A (16)	B (12)	C (8)	C (4)
	Remote (3)	B (12)	C (9)	C (6)	D (3)
	Improbable (2)	C (8)	C (6)	D (4)	D (2)
	Incredible (1)	C (4)	D (3)	D (2)	D (1)

Figure 6 - Risk Control Matrix (RCM)

Using the RCM allows for the identification of the most significant risks that should be the focus of the ALARP justification report. For instance, hazards resulting in fatalities like inadvertent firing or misfires would be examined rigorously to understand and mitigate the potential consequences.

However, the matrix alone does not form a complete risk assessment as it does not provide an absolute risk measure. For example, even if the hot barrel risk is rated as medium, actions to minimise burns, such as using heat-resistant gloves, should be considered if reasonably practicable. Actions may be required in order to validate and quantify the risks identified in the higher regions of the matrix to determine whether they meet ALARP standards. For instance, if ejected casings are classified as a medium risk, further investigation into mitigation measures, such as protective gear, may still be necessary.

2.5 List of Controls & Mitigation

- Training
- Equipment (stand)
- Muzzle
- Grip
- Stock
- PPE

2.6 Post-Control Risk Estimate

Unique ID	Likelihood Rating	Severity Rating	Risk Factor	Risk Class
AK47-01	Unlikely (2)	Minor (2)	4	Medium

ID Number	Hazard	Description	Accident	Cause	Likelihood	Severity	Risk Factor	Risk Class	Risk Reduction	Residual Likelihood	Residual Severity	Residual Risk Factor	Residual Risk Class
H1	Recoil	Force impact from the bullets energy of gas leaving the barrel	User Minor Injury (Muscular Pain) Injury sustained Major Injury	Grip/positioning Lack of training Lack of equipment	3	3	9	Medium	Training Equipment (stand) Compensator Grip Stock PPE	2	2	4	Medium
H2	Ejected casings	Casing ejects everytime shot but off chance of coming into contact with user	Burn injury sustained Eye injury	Proximity Fire rate Round Design Magazine size	3	2	6	Medium	Safety Perimeter PPE GLOVES GLASSES	2	1	2	Low
H3	Missfire	Bullet in gun does not fire as intended and instead burns inside barrel producing heat	Burn injury sustained Death	Mechanical (i.e. Firing-pin contact) Design fault/wear Compatibility (ammo) Conditions (Water, sand, heat)	4	4	16	Very High	Maintenance Approved magazines Testing	2	4	8	Medium
H4	Inadvertent Firing	Human error leading to indirect firing of gun	Minor injury sustained Wounded Multiple deaths	Lack of SQEP Fatigue Drop & Impact	5	5	25	Very High	Training Safety Culture Robust design Safety pin	2	5	10	High
H5	Hot Barrel	Build up of heat from use of weapon	Burn	Fire Rate Temp (Confinement) Wear and Tear	4	2	8	Medium	PPE Semi Auto Material design choice Maintenance	3	1	3	Low

3 ALARP Justification

In the context of this ALARP justification report, how can the risk classification for the recoil of an AK47 be reduced? Recoil is a necessary evil and cannot be avoided as it is simply part of the physics of firing a gun.

3.1 Evaluation of Recoil Reduction Methods

Recoil can be managed to reduce the felt recoil. Managing recoil happens in two ways - within the mechanics of the firearm and by the shooter. Both must work together to minimise the negative impacts of recoil. The following mechanisms are the primary methods to be implemented to reduce recoil:

- Recoil Lug
- Gas systems
- suppressor or muzzle brake
- Heavier firearms produce less felt recoil
- Ergonomic designs

Managing recoil has many advantages but if not properly managed, the accuracy and precision of the AK-47 will decrease. More importantly, managing recoil is imperative to the safety of the system as the likelihood and severity of injury for the shooter will increase if not managed correctly [8].

A recoil lug sits between the barrel nut and the action and helps to transfer the rearward energy to the stock. The recoil lug is precision machined to ensure perfectly even contact between the action and the AK-47 stock. This ensures maximum consistency from shot to shot by controlling how recoil is transferred to the stock of the rifle.

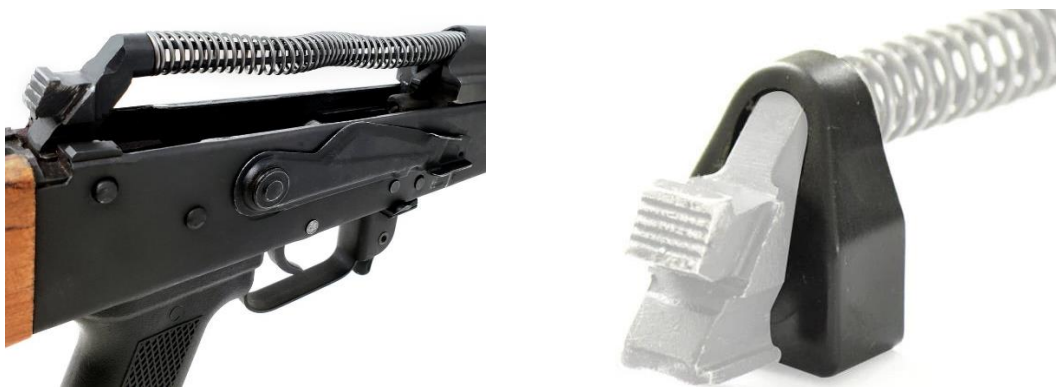


Figure 7 - Recoil Lug for AK-47

Gas systems are commonly used in semi-auto rifles and shotguns to chamber another round after the gun has been fired. Gas systems divert the high-pressure gas that builds up behind the bullet to cycle the bolt and the effect on recoil is minimal in most cases. However, specially designed gas systems like DRIV on the Savage Renegauge shotgun uses the expanding gasses to drive the bolt rearward and vents excess gas forward, resulting in significantly reduced felt recoil. Learn more about how the Renegauge DRIV gas system works.



Figure 8 - Gas systems highlighted on the AK-47

Using a suppressor or muzzle brake can help reduce felt recoil. A muzzle brake's job is to help the shooter recover from the rifle's recoil by redirecting gas through vertical baffle surfaces. As the bullet passes through the hole in the baffle, the gas behind the bullet impacts the surface of the baffle wall and this pulls the muzzle forward and reduces rearward motion of the firearm into the shooter's shoulder. Suppressors reduce felt recoil by trapping the gas as it leaves the barrel and dispersing it through the internals, which ultimately reduces the energy moving rearward as recoil.



Figure 9 - Different muzzles and suppresor for AK-47

The recoil reduction of the Dead Air Wolverine PBS-1 is the most effective. It's designed with recoil management in mind, using modern internals to significantly reduce recoil while maintaining the AK's classic look.

Heavier firearms produce less felt recoil. There's more physics involved here with the law of conservation of momentum. The recoil velocity is inversely proportional to the mass of the rifle – basically, heavier firearms have less recoil, while lighter firearms have more recoil. Long range shooters often choose heavy firearms or modify their rifles with weights to manage the recoil and all but eliminate movement at the muzzle. This is true of handguns too. Handguns with longer barrels have more forward weight which helps to counteract muzzle flip.



Figure 10 - FAB Defence M4 Folding AK-47 Stock (Stamped) w/ GK-MAG & Extra 10 rnd magazine

Ergonomic designs help shooters maintain a firm grip and keep the rifle or shotgun in line with their shoulder to absorb recoil. The shape of the comb of a stock will also affect how the recoil is transferred to a shooter's face as the gun recoils. By having the front of the comb slightly lower than the rear this moves the comb slightly away from the shooter's face. If it were to be angled up the rifle would push into the shooter's face as it recoils to the rear making for an uncomfortable shooting experience.



Figure 11 - AK-74M

The AK-47 and its variants, like the AKS-74U and AK-74, differ in recoil due to variations in barrel length, cartridge size, and weight. The original AK-47, firing the 7.62x39mm round, has manageable recoil thanks to its heavier build, which absorbs much of the force. However, lighter variants like the AKM experience more felt recoil, while compact models like the AKS-74U have increased muzzle rise despite using a lower-recoil round. In contrast, the AK-74, with its smaller 5.45x39mm cartridge, longer barrel, and muzzle brake, significantly reduces recoil, making it ideal for accuracy and control. Applying features like a muzzle brake and using lighter ammunition could similarly reduce recoil on the AK-47, providing practical recoil management without sacrificing performance.



Figure 12 - Kalashnikov AKS-74U

3.2 Preferred Option

Muzzle Brake is the best overall choice for significant recoil reduction with a moderate high cost but long-term effectiveness.



3.3 Cost Benefit Analysis

A Cost-Benefit Analysis (CBA) must be conducted to evaluate the feasibility of installing a muzzle brake on an AK-47 for recoil reduction. This involves comparing the financial costs with the potential benefits, including improved performance, enhanced safety, and a better user experience. The analysis will weigh these factors to determine whether the investment in a muzzle brake is justified based on its ability to reduce recoil risk while balancing practicality and cost.

In the UK, the initial cost of a good-quality muzzle brake typically ranges from £40 to £120, with potential installation costs of £30 to £100 for professional fitting. These costs could be reduced if it was for army as they would have internal professionals to do the work. Maintenance, including cleaning supplies, might add £10 to £25, bringing total costs to between £50 and £245. The benefits of adding a muzzle brake are substantial, with recoil reduction by 30% to 50%, leading to better control, fewer accidental discharges, and increased safety, especially for less experienced shooters. Additionally, it enhances user comfort, allowing for longer training sessions, improved accuracy, and faster target acquisition. While these benefits are harder to quantify, they can significantly improve performance in tactical situations and reduce the risk of accidents, potentially saving on medical and legal costs. Overall, investing in a muzzle brake for an AK-47 in the UK is a cost-effective choice, providing considerable advantages in safety and control that outweigh the initial expenses [9].

When considering the cost of a muzzle brake in relation to the potential life-saving benefits, the expense becomes negligible. Reducing recoil through the use of a muzzle brake can lower the risk of accidental discharge or loss of weapon control, particularly for less experienced shooters, thereby preventing potential fatalities or severe injuries. The cost of installation and upkeep is far outweighed by the value of a life saved or an injury prevented. Investing in a muzzle brake is not only cost-effective (accuracy) but also crucial for minimising risk and preserving life, an approach fully aligned with the idea that even small investments in safety can result in significant life-saving outcomes.

3.4 Justification of ALARP

A “bowtie” diagram is a way of visualising risk in just one easily understandable picture. Shaped like a bow-tie, the diagram creates a clear differentiation between proactive and reactive risk management. An effective Bow-Tie diagram results in an overview of multiple plausible scenarios, in a single picture [10].

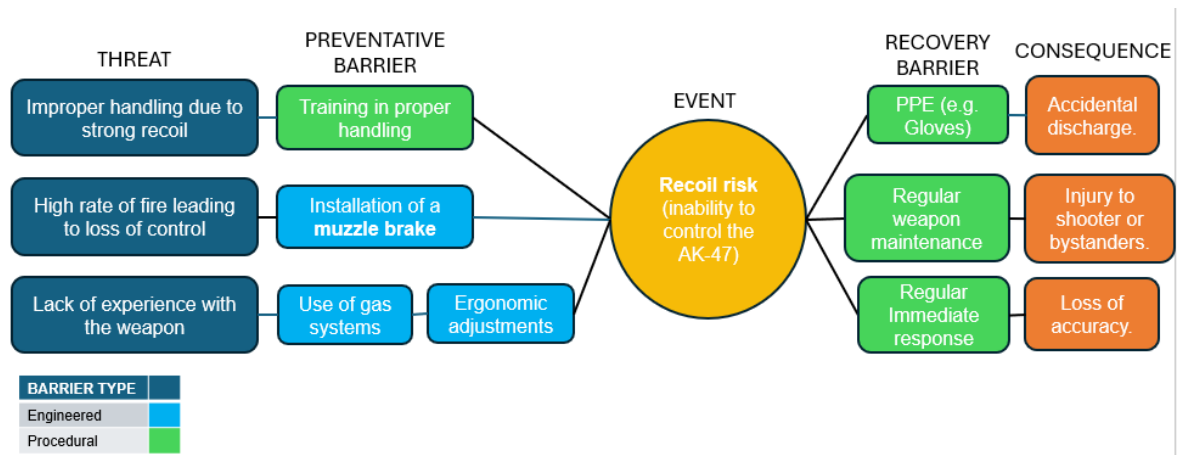


Figure 13 – Basic Bow tie diagram for an AK-47 recoil

The diagram (Fig.13/14) illustrates a comprehensive risk assessment model for the AK-47, specifically focusing on the event of recoil risk, which refers to the inability to control the weapon effectively. The identified threats include improper handling due to strong recoil, a high rate of fire leading to loss of control, and a lack of experience with the weapon. Each of these threats can lead to significant consequences, such as accidental discharge, injury to the shooter or bystanders, and loss of accuracy. Among the preventative barriers highlighted, B2 (Installation of a Muzzle Brake) emerges as a crucial Line of Defence (LOD). The muzzle brake significantly mitigates recoil, directly addressing the threats posed by improper handling and a high rate of fire. By reducing recoil, the muzzle brake enhances the shooter’s control over the firearm, thereby lowering the risk of accidental discharge and subsequent injuries.

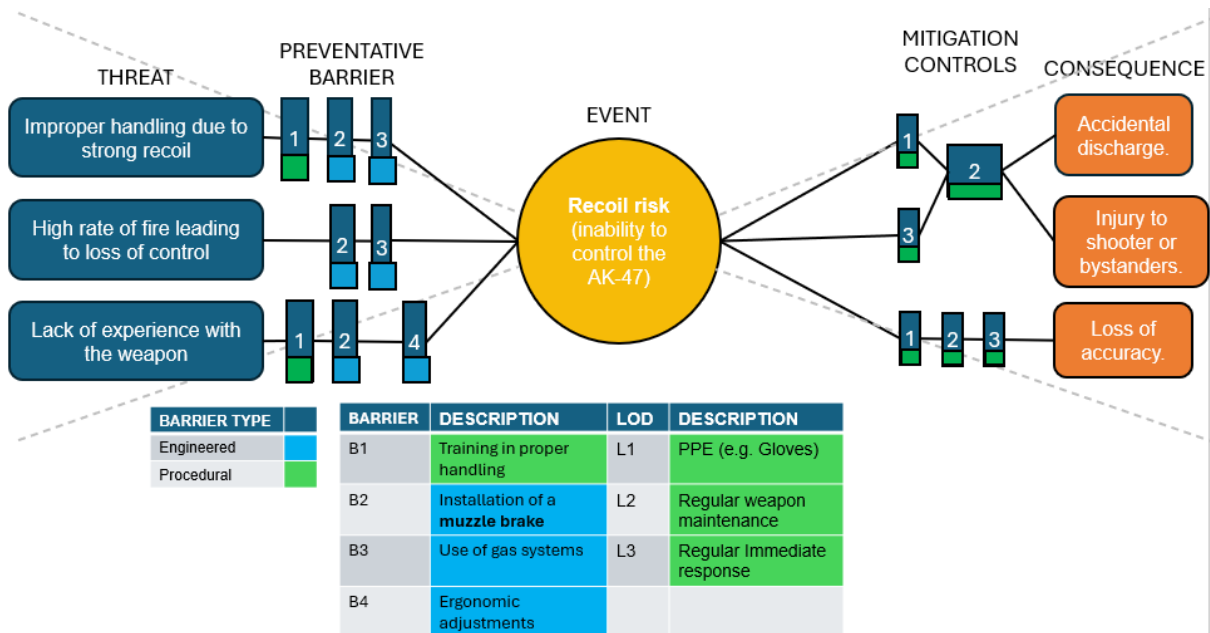


Figure 14 - Detailed Bow-Tie Diagram for an AK-47 recoil using "nodes"

In the context of the ALARP (As Low As Reasonably Practicable) principle, justifying the selection of B2 as a method for reducing risk is essential. ALARP requires that risks be mitigated to a level that is as low as reasonably practicable, balancing the cost of risk reduction with the benefits achieved. The effectiveness of B2 is a primary justification for its selection, as the installation of a muzzle brake significantly enhances the shooter's control over the weapon. This reduction in recoil directly correlates with a decrease in the likelihood of accidental discharge, aligning with risk management goals.

3.4.1 Swiss Cheese Model

The Swiss Cheese Model is illustrated in the provided diagram, which represents how various layers of defence can mitigate hazards associated with firearm operation, specifically the AK-47 [11].

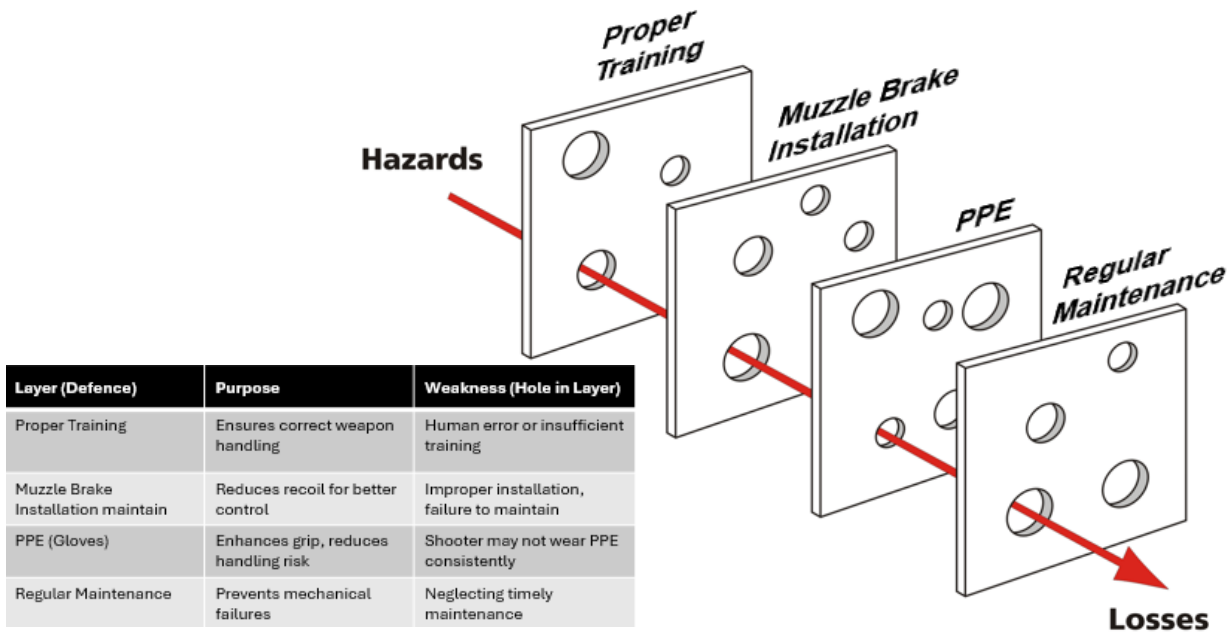


Figure 15 - Swiss Cheese Model for AK-47 Recoil

Each layer, depicted as a slice of Swiss cheese, addresses specific hazards. Starting from the left, the first slice represents Proper Training, ensuring users are well-versed in safe handling and operation. The second slice emphasises the importance of Muzzle Brake Installation to reduce recoil and enhance control. The third layer highlights the role of Personal Protective Equipment (PPE), which safeguards users from potential injuries. Finally, the last slice denotes Regular Maintenance, ensuring that the firearm remains in optimal working condition. The red arrow signifies the pathway from hazards to losses, illustrating that if the holes in each layer align, an incident may occur, leading to potential losses. This model effectively underscores the necessity of multiple protective measures in maintaining safety when operating firearms.

4 Conclusion

In conclusion, this report provides a thorough hazard identification and risk assessment of the AK-47, focusing specifically on the recoil hazard and its implications for user safety. By employing a collaborative approach among team members and adhering to the ALARP principle, the report successfully identifies critical hazards associated with the lifecycle of the AK-47, from manufacture to target disposal. The analysis emphasises the need for effective risk mitigation strategies, with the installation of a muzzle brake being highlighted as the most viable solution for managing recoil. Through a detailed Cost-Benefit Analysis, it is demonstrated that the benefits of implementing a muzzle brake—ranging from significant recoil reduction to enhanced user comfort and safety—far outweigh the associated costs. Overall, this report underscores the importance of proactive hazard management and compliance with safety regulations, ultimately contributing to the development of safer firearm designs and operational practices. The insights gained from this assessment provide a valuable foundation for future efforts aimed at improving safety standards in the firearms industry.

5 Appendix

	Insignificant (1)	Minor (2)	Significant (3)	Major (4)	Severe (5)		Lower	Higher	Tolerability			Likelihood		Severity	
Frequent (5)	Medium (5)	High (10)	Very High (15)	Very High (20)	Very High (25)	Low	1	3	Broadly Acceptable			Frequent	1-100	Negligible	No Injury
Likely (4)	Medium (4)	Medium (8)	High (12)	Very High (16)	Very High (20)	Medium	4	9	Tolerable if ALARP			Likely	100-1000	Minor	Minor Injury
Occasional (3)	Low (3)	Medium (6)	Medium (9)	High (12)	Very High (15)	High	10	14	Tolerable if ALARP			Occasional	1000-10000	Significant	Major Injury
Unlikely (2)	Low (2)	Medium (4)	Medium (6)	Medium (8)	High (10)	Very High	15	25	Intolerable			Unlikely	10000-100000	Major	One Death
Improbable (1)	Low (1)	Low (2)	Low (3)	Medium (4)	Medium (5)							Improbable	100000-1000000	Severe	Multiple Deaths

ID Number	Hazard	Description	Accident	Cause	Likelihood	Severity	Risk Factor	Risk Class	Risk Reduction	Residual Likelihood	Residual Severity	Residual Risk Factor	Residual Risk Class
H1	Recoil	Force impact from the bullets energy of gas leaving the barrel	User Minor Injury (Muscular Pain) Injury sustained Major Injury	Grip/positioning Lack of training Lack of equipment	3	3	9	Medium	Training Equipment (stand) Compensator Grip Stock PPE	2	2	4	Medium
H2	Ejected casings	Casing ejects everytime shot but off chance of coming into contact with user	Burn Injury sustained Eye injury	Proximity Fire rate Round Design Magazine size	3	2	6	Medium	Safety Perimeter PPE GLOVES GLASSES	2	1	2	Low
H3	Missfire	Bullet in gun does not fire as intended and instead burns inside barrel producing heat	Burn Injury sustained Death	Mechanical (i.e. Firing-pin contact) Design fault/wear Compatibility (ammo) Conditions (Water, sand, heat)	4	4	16	Very High	Maintenance Approved magazines Testing	2	4	8	Medium
H4	Inadvertant Firing	Human error leading to indirect firing of gun	Minor injury Injury sustained Wounded Multiple deaths	Lack of SQEP Fatigue Drop & Impact	5	5	25	Very High	Training Safety Culture Robust design Safety pin	2	5	10	High
H5	Hot Barrel	Build up of heat from use of weapon	Burn	Fire Rate Temp (Confinement) Wear and Tear	4	2	8	Medium	PPE Semi Auto Material design choice Maintenance	3	1	3	Low

		Severity						
		Catastrophic (4)	Critical (3)	Marginal (2)	Negligible (1)	Severity	Direct Personnel	Indirect Personnel
Likelihood	Frequent (6)	A (24)	A (18)	A (12)	B (6)	Catastrophic	Multiple deaths	A single death and / or multiple severe injuries or equivalent occupational illness
	Probable (5)	A (20)	A (15)	B (10)	C (5)	Critical	A single death and / or multiple severe injuries or equivalent occupational illness	A single severe injury or occupational illness and / or multiple minor injuries or minor occupational illness
	Occasional (4)	A (16)	B (12)	C (8)	C (4)	Marginal	A single severe injury or occupational illness and / or multiple minor injuries or minor occupational illness	At most a single minor injury or minor occupational illness
	Remote (3)	B (12)	C (9)	C (6)	D (3)	Negligible	At most a single minor injury or minor occupational illness. A non-sporting injury requiring professional medical attention (may include a Medical Orderly or an Army Combat Medical Technician)	Any injury or occupational illness, however minor
	Improbable (2)	C (8)	C (6)	D (4)	D (2)			
	Incredible (1)	C (4)	D (3)	D (2)	D (1)			
						Likelihood	Qualitative	Quantitative
						Frequent	Likely to be continually experienced during the life of the system	$> 10^{-3}$ per individual per system per year
						Probable	Likely to occur often during the life of the system	10^{-3} to 10^{-4} per individual per system per year
						Occasional	Likely to occur several times during the life of the system	10^{-4} to 10^{-5} per individual per system per year
						Remote	Likely to occur sometime during the life of the system	10^{-5} to 10^{-6} per individual per system per year
						Improbable	Unlikely, but may exceptionally occur during the life of the system	10^{-6} to 10^{-7} per individual per system per year
						Incredible	Extremely unlikely that the event will occur during the life of the system	$< 10^{-7}$ per individual per system per year
						Risk Class	Definition	Risk Factor Range
						A	Intolerable, and shall not be accepted. A formally delegated person may only accept this risk in extraordinary circumstances.	12 to 24
						B	Undesirable, and shall only be accepted by the PTL, or equivalent, when further risk reduction is impracticable.	6 to 12
						C	Tolerable with the endorsement of the Safety Committee if risk is demonstrated to be ALARP.	4 to 9
						D	Broadly acceptable, but risk shall be monitored by the Safety Committee to ensure that it remains ALARP.	1 to 4