

New Blast Weapons

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ABSTRACT

Over the last decade a large number of weapon systems have appeared that use blast as their primary damage mechanism. This is a notable trend; until recently very few warheads relied on blast as their primary output. Most warheads in service use explosives to drive metal such as fragments and shaped charge jets to engage targets. New technologies are now being integrated into warheads that claim to have enhanced blast performance. Blast weapons could have been designed to fill a gap in capability; they are generally used for the attack of 'soft' targets including personnel, both in the open and within protective structures.

With the increased number and range of these weapons, it is likely that UK forces will have to face them in future conflicts. This paper briefly describes fuel-air explosive blast weapons and reviews a range of enhanced blast weapons that have been developed recently. The paper concludes with a brief discussion on the reasons why enhanced blast technologies may be proliferating and how this could affect the Defence Medical Services.

Introduction

Chemical energy and kinetic energy are used to attack military targets. Energetic materials such as propellants may be used to accelerate inert projectiles for the direct attack of personnel and materiel by kinetic energy. The energetic material may also be transported to the target for direct or indirect attack by chemical energy. The most common approach is the indirect attack of targets by the chemical energy - using explosive to drive fragments (such as mortars and shells) or shaped-charge jets (such as LAW 80).

Weapon systems have harnessed the power from explosive blast for many years. Early weapons used gunpowder until the development of high explosives such as TNT (2,4,6-trinitrotoluene). Military research has focused on improving the performance of high explosives to improve the effectiveness of weapon systems. Explosives are generally the principal means of harnessing enormous amounts of energy to attack a target. When the warhead is initiated, the high explosive detonates generating very high pressure

gasses which rapidly expand and do work on their surroundings. The work may be expended in fragmenting the warhead case or forming a shaped charge jet; some of the energy from the explosion manifests itself as a blast wave in the surrounding air. Traditionally, very few conventional munitions use the blast wave to directly engage a target. One such example is an anti-personnel mine where there are few, if any, metallic components to act as fragments. The primary output of the mine is blast and this can have a devastating effect on the limb in contact with the mine. Shaped charge warheads are rarely used for attacking personnel; they are primarily designed to defeat armour but there are ammunition natures such as bomblets in artillery munitions that combine shaped-charge jets with a secondary anti-personnel fragmentation role to suppress infantry.

Fragmenting munitions (e.g. hand grenades, mortars and shells) are widely used in conflicts because of their effectiveness against a wide range of targets, including personnel. Over time, there has been a shift towards increasing the effectiveness of weapon systems by optimising their fragmentation output: notched cases, wire wound cases, pre-formed fragments and specially designed liners around the explosive.

Warhead designers have been developing means of directing the explosive energy in warheads to attack specific targets. Advances in energetic materials have improved upon the explosive performance of early explosive compositions such as TNT to more modern Polymer Bonded Explosives which have an output of about 1.5 times that of TNT (based on pressure and impulse).

Most of the advances in energetic materials have been towards improving the performance of explosives for driving metal (fragments and shaped charges) with only a small amount of development towards improving the blast performance.

There is now emerging evidence that enhanced blast explosives have been developed and are being used in a number of weapon systems. Until recently, blast was only utilised in specialised weapons such as fuel-air explosive (FAE) air delivered bombs. Sales literature and other publicly available promotional literature indicates that enhanced blast explosives are now being

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used in a range of munitions from small grenades through to large calibre rockets.

This paper reviews the developments in weapons designed to attack materiel and personnel with blast. The information presented in this article is derived from sources in the public domain. Before reviewing these weapons, it is of value to briefly consider the merits, or otherwise, of blast and fragmenting munitions.

Blast versus fragmentation

For a conventional high explosive charge, the energy available in a blast wave decays very quickly with increasing range. The decay of the blast wave is strongly influenced by the environment in which it is detonated - for example the decay will be significantly less if the warhead is detonated within a structure, compared with one detonated in the open. Blast waves can diffract around corners and the expanding gases can rapidly propagate throughout a structure. Reflections from surfaces also increase the overall blast load to objects within a structure, and upon the structure itself. Blast weapons are effective when used in confined spaces or built up areas.

Fragmenting munitions have a relatively high casing/explosive mass ratio. The primary purpose of the explosive is to create and propel fragments. The lethal range of these fragments is far greater than the lethal radius from the blast generated by the explosive. However, the probability of being hit by one of the fragments reduces significantly with range as the fragments diverge in space. Fragmenting munitions are most effective when used in the open. Obstacles such as walls can provide significant protection by stopping or slowing down the fragments. Furthermore, fragments do not go around corners, although they can ricochet. Fragmenting munitions are often used in a suppression role. Soldiers in battlefield trenches are well protected from artillery shell fragments (unless there is a direct hit).

In current and future operations, collateral damage will be a principal concern, especially with regard to personnel. In these scenarios, the use of fragmenting munitions may be limited due to the indiscriminate nature of the fragment throw. Blast weapons may well offer the most effective means of providing low collateral damage munitions. Blast weapons have a well defined and limited area of effectiveness due to the rapid decay of the blast wave. Figure 1 shows how the lethal radius of blast and fragmenting munitions compare in the open.

Blast waves and targets

The interaction of blast waves with targets is covered in detail in another article in this Journal (Cullis). Blast is not ideally suited to the attack of all types of target. When faced with a main battle tank, one would probably

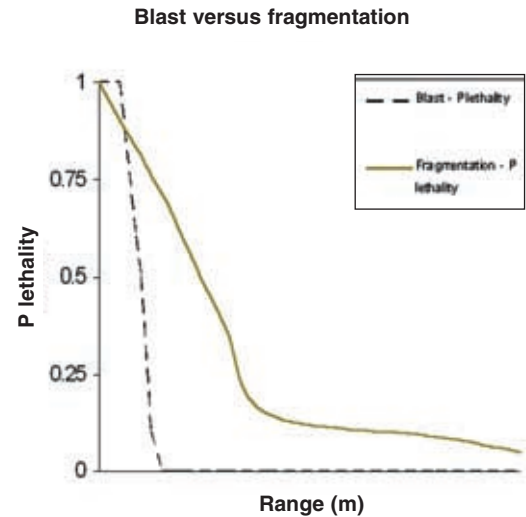


Fig 1. Comparative blast and fragmentation lethality radii for a 900g warhead in the open.

select a weapon such as LAW80 that is designed to defeat the armour. However, if one was faced with enemy soldiers in a protected structure then LAW80 would not be the ideal choice - a shoulder-launched rocket with a wide area of effect may be more appropriate. Blast and fragmenting munitions fall into this general purpose category. Some targets such as personnel are susceptible to a wide range of damage mechanisms (blast, fragments, thermal load etc.).

F AE weapons with their relatively long impulse and blast overpressures are ideally matched to soft targets such as aircraft, unreinforced buildings, missiles, un-armoured vehicles, communication equipment and personnel.

Fuel-air explosives

A number of nations including the United States (US) and Former Soviet Union (FSU) have developed fuel-air explosive weapon systems. The primary damage mechanism of such devices is blast. There is very little primary fragmentation associated with FAE weapons. Relative to conventional explosive weapons, the blast output can be several times greater. FAE warheads generally require atmospheric oxygen to detonate. The warheads carry a liquid hydrocarbon that is dispersed in the atmosphere on initiation (the contents can either be explosively dispersed or dispersed under pressure). The un-detonated vapour cloud expands into the atmosphere mixing with atmospheric oxygen. At some pre-determined time after dispersion, a second explosive charge is initiated within the vapour cloud. This detonates the vapour cloud generating a strong blast wave. The density of the detonating medium is lower than conventional explosives leading to lower blast pressures compared to conventional explosives. However, the cloud covers a large area and so the effect of such a weapon covers a considerably greater area than could

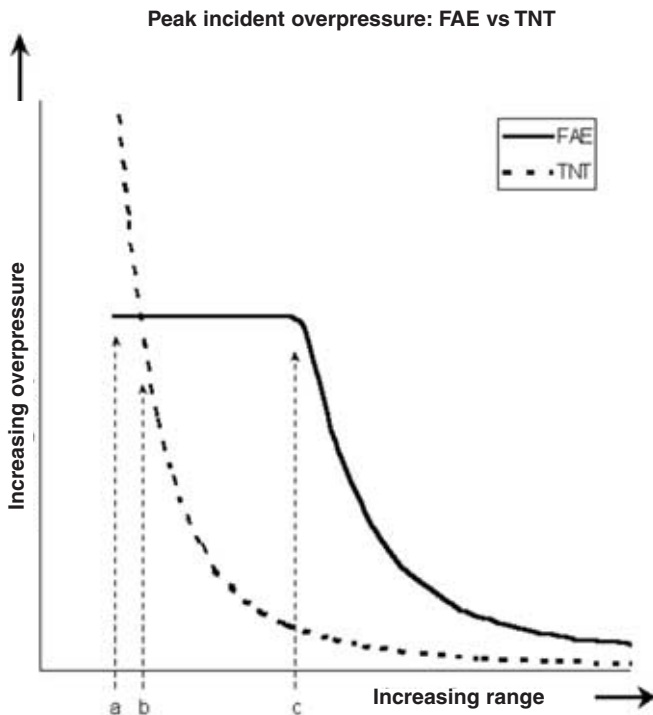


Fig 2a. Overpressure for 1 kg TNT and 1 kg Ethylene Oxide (FAE).

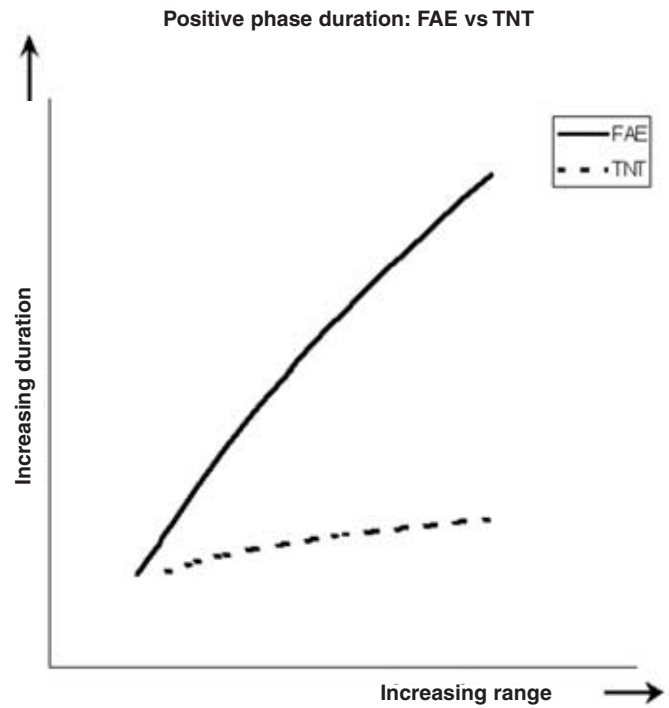


Fig 2b. Blast wave duration for 1 kg TNT and 1 kg Ethylene Oxide (FAE)

be achieved with conventional solid explosives of a similar mass. Figure 2 compares the fall of peak pressure with distance for 1kg of TNT and 1 kg of Ethylene Oxide (a fuel commonly used in FAE weapons).

The blast waves produced by FAE weapons differ from conventional high explosives such as TNT. Close-in to the explosion, conventional condensed military explosives have a very high peak pressure and a relatively short duration. Close-in to FAE explosions, the peak pressures are lower than for TNT (Figure 2a, 'a') but the duration of the blast wave is significantly longer. Because the blast wave from TNT decays more quickly than FAE (Figure 2a, 'b') it is less effective in the mid-field. The peak pressure of the blast wave inside the fuel air cloud remains fairly constant out to the periphery of the cloud (Figure 2a, 'c') where the blast then decays in a similar manner to TNT. Figure 2a shows that at mid to far field from the explosion, the pressure from the FAE system is much greater. Coupled with this, the duration of the FAE blast waves are greater (Figure 2b). The impulse (pressure x presented area x time) is a measure of the ability of the blast wave to do work on a structure; the impulse in the FAE blast wave is significantly greater than TNT.

Disadvantages of FAE

Although this class of weapon appears to offer many performance advantages, there are problems associated with the design, storage and functioning of such a device. To achieve the optimum output from an FAE weapon, it is important to ensure that the vapour cloud has reached the correct

stoichiometry (mixing with the air). At that precise time, a second explosive charge must operate to start the detonation process of the cloud. The evolution of the cloud could be affected by atmospheric conditions, high winds, rain and temperature extremes. Overall, the successful detonation of a fuel-air cloud can be a tricky procedure.

Today's Blast Weapons

Fuel Air Explosive systems

The US have a number of fuel air warheads in their arsenal ranging from BLU-64/B carrying 200kg of a fuel through to BLU-72B Pave Pat 2 carrying 1,202 kg of ethylene oxide (Jane's Air Launched Weapons). The US have apparently limited their use of fuel-air explosive air technology to air delivered bombs; they have had specialised FAE warheads in their inventory since the 1960s (Lavoie 1989).

An article in the Sunday Times (Walker 2000) suggested that the use of FAE bombs was threatened by the US during the Kosovo conflict. It was reported that the US sent a video to Yugoslav army generals showing the devastating effect of FAE weapons. It also suggested that the dramatic effects of such weapons caused Slobadan Milosevic to reconsider his position.

The FSU have also developed a range of air delivered fuel air weapons such as ODAB-500PM (images on www.aeronautics.ru/nws002/janes014.htm) and KAB-500Kr. The ODAB-500 PM bomb has been developed by Russia to provide the Russian Air Force with a high speed low-level attack fuel-air explosive weapon for use against troops and material in the field. Both of these

weapon systems are designed for the attack of blast-sensitive targets including personnel. The ODAB-500 PM bomb contains 193kg of an unknown high energy explosive fuel. It is claimed that the bomb's effective range against infantry in the open is a 30m radius (almost 3000m²) (Jane's Air Launched Weapons).

An article in Jane's Intelligence Review (June 1995) demonstrated how such a weapon could be used with devastating effect by ground forces. ODAB 500's have also been modified so that they can be launched from the back of a vehicle rather than dropped from an aircraft. This weapon system was reported to have been used by Serbian forces to bombard Bihac.

China has also developed fuel-air explosive cluster bombs. Jane's Air Launched Weapons reports that in 1990 two sizes of bomb were being developed: a 250kg bomb carrying 2 bomblets and a 500kg bomb carrying 3 bomblets. The manufacturer claims that the destruction radius for a single bomblet is 30m for aircraft, 40m for mines and 50m for personnel (nearly 8000m²!).



Fig 3a. Pack of two RPO-A Shmel rocket infantry flame-throwers (T J Gander 2000)



Fig 3b. Pack of two RPO-A Shmel rocket infantry flame-throwers, as issued (T J Gander 2000).

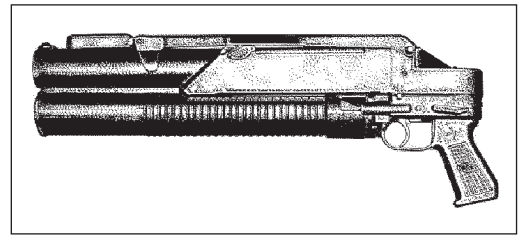


Fig 4. GM-94 43mm magazine grenade launcher (L Haywood 1999).

A new generation of enhanced blast explosives

In addition to traditional fuel-air munitions, it appears that Soviet scientists have also developed a new range of enhanced blast munitions. Over the past decade there have been a large number of weapon systems appearing that appear to deploy a new enhanced blast explosive technology. A number of descriptions, including volumetric and thermobaric are being used to describe what appears to be an advance in explosives technology. Volumetric appears to imply some form of advanced fuel-air explosive technology; thermobaric implies an enhanced blast explosive that also generates a significant thermal output.

One of the first systems claimed to employ this new technology was the Soviet infantry flame-thrower RPO-A (Figure 3a and 3b). This is described in detail in Jane's Infantry Weapons 2000-01. RPO-A is issued to airborne and marine assault troops to destroy strong-points such as bunkers or lightly armoured vehicles. RPO-A (Russian name – Shmel) is a single-tube launcher normally carried in pairs. It has a simple optical sight calibrated to 600m.

The warhead is 93mm in diameter and contains 2.1kg of a thermobaric composition. Literature claims that when detonated inside a structure, the destructive effects cover 80m³ (Jane's Infantry Weapons 2000). RPO-A is designed for the attack of blast-sensitive targets including personnel. This weapon was reported to have been used extensively by the Russian army in the Chechen conflict 1994-95. It is also reported to be the most widely available thermobaric weapon (Leaf 2000).

RPO-A is without doubt a very valuable addition to the Russian infantry weapons. For the first time, the infantry have the ability to deliver remotely relatively large quantities of explosive to the target. This will allow them to take on a much wider range of targets effectively, including personnel in the open and in protective structures.

The smallest weapon system utilising enhanced blast explosives is a magazine-fed slide-action grenade launcher, GM-94 (Figure 4). The launcher fires a variety of 43mm cartridges including fragmentation, shaped charge and thermobaric. No performance data for these small grenades is quoted.



Fig 5. TBG-7V, a thermobaric warhead for the RPG-7 launcher (T J Gander).

Recently more advanced weapon concepts have been being marketed. The RShG-1 is a multi-purpose assault weapon designed to defeat lightly armoured vehicles, field fortifications and concrete structures. A single RShG-1 is claimed to be effective against personnel sheltered in confined spaces of up to 300m³, or in the open with a radius of up to 10m. This weapon is thought to be in production and is offered for export sales; it is probably in service with Russian military forces (Jane's Infantry Weapons).

A number of warheads exist for the RPG man-portable short-range rocket system. A fuel-air thermobaric warhead has now been developed for the RPG (Figure 5). The warhead weighs approximately 4.5 kg and has a maximum range of 700m. The warhead is claimed to be able to 'disable personnel in trenches or bunkers (with the grenade detonating 2m from the trench or bunker)'. It is also claimed that the warhead is effective over a 10m radius in open terrain (Jane's Infantry Weapons).

Enhanced blast warheads have also been developed for a range of guided missiles. AT-6 'Spiral' is a helicopter launched anti-tank weapon and is believed to have a fuel-air or thermobaric type warhead (Figure 6). AT-9, a guided missile launched from a vehicle platform, also boasts an FAE option for use against static targets. Kornet, AT-14, a long range anti-tank guided weapon also can be fitted with a enhanced blast warhead (Figure 7). Metis-M is a crew served weapon originally designed for the attack of armoured targets (Figure 8). An updated missile has been developed that contains a 4.95 kg thermobaric warhead for the attack of bunkers and similar targets.

Khrizantema is a dual anti-armour/anti-



Fig 7. Kornet launch unit (T J Gander).

bunker weapon being developed by the KBP Instrument Design-Making Bureau (Figure 9). The weapon can be mounted on a BMP-3 tracked infantry fighting vehicle and has a range of 6km. One of the warhead options is fuel-air explosive for the attack of bunkers (Jane's Infantry Weapons).

Russia has also developed an enhanced blast explosive warhead for their unguided air-launched rocket range, S8. The variant S8-DM is quoted as having a 3.6 kg FAE warhead.

Very few anti-ship weapon systems are reported to have been modified to take advantage of enhanced blast explosives. This is somewhat puzzling since blast is a particularly effective damage mechanism against ships.

Probably one of the most devastating weapon systems to deploy enhanced blast explosive technology is TOS-1 'Buratino' (Figure 10). This is a purpose built weapon system designed to deliver a large payload over a large area. The weapon system appears to have been specifically designed to deploy enhanced blast explosive technology. Russian sales literature states that 'Fighting vehicle TOS-1 is designed for defeating the enemy manpower on the open country and in defences...'. It has a range of up to 5.5 km and can launch 30 220mm rockets in under 8 seconds (VTTV-Omsk-99) (Figure 11). The Buratino is reported to have been the main thermobaric delivery system that the Russians used against Grozny (Grau 2000).

TOS-1 may not be the only Multiple Barrel Rocket Launcher (MBRL) that is capable of delivery enhanced blast warhead.



Fig 6. MT-LB tracked vehicle with AT-6 launcher in elevated position (Christopher S Foss).



Fig 8. Metis-M launcher with missile (T J Gander).



Fig 9. The Khrizantema dual anti-armour/anti-bunker weapon system mounted on a BMP-3 infantry fighting vehicle (1997). Taken from www.geocities.com/area51/capsule/6480/at15htm.

Two other MBRLs are believed to be able to deliver fuel-air explosive warheads, Splav 220mm (Uragan) BM 9P140 220mm launcher with 16 rounds and Splav 300mm (Smerch) BM 9A52 300mm launcher carrying 12 rounds (Jane's Ammunition Handbook).

Discussion

Enhanced blast technology is emerging across a wide range of weapon systems. Small devices such as the 43 mm grenade launcher with a range of a few tens of metres through to long range MBRLs capable of delivering large payloads over many tens of kilometres, are either in-service or under development.

It does not appear that these enhanced blast weapons are being developed and deployed to replace conventional warheads such as fragmentation and shaped charge. They appear to have been designed to complement the current inventory. Russia appears to be at the forefront of these developments and has probably gained a great deal of experience through conflicts such as Afghanistan and Chechnya. These experiences may have led to their blast weapon development programmes which in turn has led to their emergence in service

and for purchase at arms fairs.

Of key importance is the fact that personnel are invariably within the target types quoted for these weapons. Blast is an effective means of killing/incapacitating people either by the direct effects of the blast wave on the body or by indirect effects such as secondary projectiles, high thermal loads causing burns, particularly to exposed skin such as the face, and crush injuries caused by the collapse of structures. The principal direct injury caused by the interaction of the blast wave is blast lung. This is a pulmonary contusion produced by the pressure wave entering the thorax. The clinical sequelae and management principles are discussed elsewhere in this Journal (Horrocks), but this is a serious injury that may have both acute and long-term effects on the military performance of personnel, and may provide significant clinical and logistic challenges for military medical services. The blast waves may also produce contusions and perforations to small and large bowel.

Although the performance of enhanced blast technology - fuel-air or thermobaric - is undoubtedly an improvement over conventional explosives such as TNT, there is no evidence that they offer orders of magnitude enhancements. They are employing a damage mechanism that has not been fully exploited. Blast has a very clearly defined lethal radius, and may be the solution to many of the problems raised by the current need to reduce collateral damage.

It is quite probable that future conflicts will involve Urban Operations. These types of weapon are well suited to this environment, thus it is more likely that UK forces will encounter them in the future.

Currently, protection issued to the armed forces is designed to stop bullets and fragments. Protective clothing such as the UK Combat Body Armour (CBA) is very effective at protecting against fragments, but in common with all vests of this general type used by armed forces world-wide, it offers no protection to the direct effects of blast on the body. It is possible to significantly reduce the blast energy entering the body and thus the



Fig 10. TOS-1 (VTTV-Omsk-99).



Fig 11. TOS-1 firing missiles in pairs (VTTV-Omsk-99).

incidence of injuries such as blast lung. One approach is to use decouplers - layers of materials with different acoustic and mechanical properties that attenuate shock waves. Protective clothing designed to mitigate the direct effects of blast does exist - for example, the UK Mk4 EOD suit - and research at DERA is underway to develop protective clothing that is lighter in weight, more flexible and of minimal bulk.

There is now the potential to see a significant change in the types of injuries in future conflicts. The types of injury that we would expect to see from enhanced blast weapons are not new *per se*, but the incidence of injuries such as blast lung, burns and crush may rise. There will be implications for the Defence Medical Services in clinical doctrine, scaling of equipment and the training of staff.

Summary

Enhanced blast technology is apparently being used in many weapon systems (principally of Russian origin) providing armed forces and militia with a improved ability to engage a wide range of 'soft' targets, including personnel. Historically many of the injuries experienced during conflicts were penetrating wounds caused by fragmentation and bullets. Blast weapons have very little fragmentation associated with them; the payload is optimised to deliver the largest blast charge possible. The injury mechanisms associated with these weapons are likely to be the direct effects of the blast on the body such a blast lung, burns to exposed skin and crush injuries due to the collapse of buildings. These are not novel injuries *per se*, but their incidence will increase in operations where blast weapons are used.

It does not appear that enhanced blast weapons are being developed to replace

conventional fragmenting munitions; it is more likely that their purpose is to expand the capability of the fighting soldier. Blast weapons may be particularly suited to Urban Operations where systems like RPO-A are reported to have been used (such as in Chechnya). Blast may also be one of the practical solutions to low collateral damage weapons, by replacing fragmenting munitions that have very large lethal areas due to fragment throw.

With increased numbers of enhanced blast weapons being developed and marketed, it is becoming increasingly likely that UK forces will have to face them at some time in the future. The Defence Medical Services must be prepared for this challenge.

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