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Directions of Artillery Development on the Example of the US Military and Artillery Use in the Baltic Sea Region

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Abstract

This article discusses role of field artillery on battlefield and the current state of field artillery. The purpose of this article is to outline development directions of artillery capability. Army surface-to-surface indirect fires will have a crucial part on the future battlefield. Essential trends in field artillery include: increase in range of fires systems; develop and disseminate of multi-sensor active-seeker munitions; advancement automated command and control; develop and implementation systems order to protect ground forces and forward operating bases from the threat of rockets, artillery, and mortars (C-RAM).

Keywords: fires, field artillery, defense, technology development

1. Introduction

Modern artillery is one of the components of fire support (FS) and it is found in every modern army. The Field Artillery (FA) is one of the basic types of land forces designed to perform fire support tasks. FA is consisted of headquarters and units, as well as fire, reconnaissance and logistic units. Since very beginning of this military brand it was a subject of science discussion concerning modern solution (Walter, 1880) and future development (Walford, 1891) (Sawhney, 1984). Currently, the process of replacing and modernizing equipment in artillery units is underway. The components introduced into service are equipped with fire platforms, command vehicles, reconnaissance systems, logistic facilities and special-purpose ammunition.

The large differentiation in the intensity of the number of fire platforms is illustrated by the conflict in Ukraine. For example, on the morning of July 11, 2014, the Ukrainian 24th Mechanized Brigade was moving near Zelenopillya (Luhansk Oblast, eastern Ukraine), approx. 10 km from the border with Russia. After occupying the designated area, the Ukrainian forces found interference with their communication and navigation systems. Around 4.20am, unmanned aerial vehicles were spotted watching the columns. Then there was a rocket attack. Around 40 salvos of Russian rockets hit the Ukrainian position. During the five-minute fire attack, the equipment of two battalions was destroyed. This incident was not the only one and caused alarm among western officials (Watling, 2019, p. 8). The great fire possibilities and short reaction time of modern artillery systems are shown by rocket attack. It should be emphasized that the Russian motorized brigade has 81 organic units of artillery equipment (Sutyagin, and Bronk, 2017, p. 30). The organic artillery includes self-propelled howitzers (152 mm and 203 mm) and 300 mm MLRS systems (Multiple Launch Rocket System). In addition, the brigade includes an electronic warfare battalion (Watling, 2019, p. 2). The battalion tactical group has about 18 self-propelled guns (Fox, and Rossow, 2017, p. 6) and can receive support from the MLRS at the brigade level. This illustrates the high saturation with artillery and electronic warfare systems in branches and subunits of the Russian army. In order to reduce the divergence of fire possibilities it is necessary to develop modern artillery systems.

The aim of this work is to present the role of field artillery and to describe the directions of development. Due to the nature and limited scope of this article, the discussion is limited to the most crucial ideas and problems. The article was mainly based on an analysis of the artillery of USA and Russian Federation (RF). Theoretical research methods such as: analysis and synthesis of information comprised in literature and source materials, as well as the inference method were used to develop this article.

2. Role of field artillery

Army surface-to-surface indirect fires includes cannon, rocket, and missile systems as well as mortars organic to maneuver elements. It is necessary to identify the rules of use and tasks of artillery to indicate the future of artillery. The rules for the use of artillery follow the rules of the art of war and include:

- Purposefulness of actions - in relation to artillery, it indicates the need to formulate its tasks aimed at achieving the combat goal. The tasks are assigned to the artillery subunits by the general military commander, in accordance with the purpose and intention of fighting and in accordance with their combat capabilities.
- Activity - is expressed by the constant fire attack on the opponent. Being active also means showing initiative in the way of performing tactical tasks by using various types of fire adequately to the reconnaissance information and types of ammunition.
- Economy of forces - requires commanders at all levels to rationally dispose of the artillery potential. It boils down to observing the rule of designating a sufficient number of fire platforms to perform the assigned tasks. Higher effectiveness of FS can be achieved by focusing fire on high-value targets (HVT) located in key directions (regions). The concentration

of fire is achieved by decentralized operation of artillery subunits with the possibility of its centralization. This is based on the operation of artillery subunits that would provide support to the fighting units and would also enable them to independently perform the tactical tasks they receive. In critical moments of combat, however, it must be possible to centralize the artillery command in order to concentrate the FS effort. This requires the constant selection of HVT and hitting them with separate platforms.

- Maneuverability - performs two basic functions in artillery. It enables the efficient reception of an appropriate formation and a systematic maneuver between regions in order to occupy a convenient formation to perform tactical tasks. Maneuver enables focusing and shifting the fire effort on the most important directions of activities. It is subordinated to the principle of the economy of power and the need to ensure the continuity of FS for troops. Maneuverability is also a method of maintaining combat vitality. The implementation of this principle is ensured by the maneuverability of artillery units (the ability to cross a variety of terrain) and their armor.
- Surprise with artillery fire - is expressed by unexpected fire for the opponent with high intensity. Combat capabilities of artillery guarantee achieving this effect. Compliance with the principle of surprise is essential for the effectiveness of artillery fire. Fire made by surprise is highly effective, measured by the amount of material and psychological losses of the opponent. The greatest effects of a fire resulting from a surprise are achieved in the initial moment of its conduct. Fire for effect should be precise, intense and conducted in a short period of time. It should be performed when the opponent is out of cover (trenches, armored vehicles), then his orientation is difficult and the routine counteracting the effects of fire is disturbed. The surprise is also obtained by precisely recognizing the enemy and keeping the artillery's maneuver preparing to open fire in secret.
- Maintaining combat capability - compliance with this principle consists in using artillery in such a way that will ensure its constant readiness to perform FS throughout combat. This means the necessity of rational management of human and material potential. In order to maintain combat capability, an appropriate formation of artillery units should be received. Moreover timely relocations to the next, more convenient areas, including the change of gun fire positions immediately after each fire task should be completed (Działania, 2016, p. 11-14).

In line with US doctrines, the role of the field artillery (FA) is **to destroy, neutralize, or suppress** the enemy by cannon, rocket, and missile fire and to integrate and synchronize all fire support assets into operations. Fire support is fires that directly support land, maritime, amphibious, and special operations forces to engage enemy forces, combat formations, and facilities in pursuit of tactical and operational objectives (ADP 3-19, 2019, p. 21).

The basic tasks of artillery in accordance with the Polish nomenclature include:

- Close Supporting Fire;
- Deep Supporting Fire;
- Counter Battery Fire;
- Command and Control Warfare;
- Suppression of Enemy Air Defense (*Działania*, 2016, p. 15).

Close support fire is artillery fire placed on enemy troops, weapons, or positions which, because of their proximity, present the most immediate and serious threat to the supported unit. **Deep Supporting Fire** is artillery fire directed at objectives not in the immediate vicinity of our forces, for neutralizing and destroying enemy reserves and weapons, and interfering with enemy command, supply, communications, and observations. It is carried out to prevent and disorganize the approach and deployment for action, reduce the enemy's combat potential and disrupt the supply system. **Counter Battery Fire** is the primary task of a division's artillery. Counter Fire is a battlefield military activity to defeat the enemy's indirect fire elements (guns, rocket launchers, artillery and mortars), including their target acquisition, command and control components. This task is carried out artillery units independently or in cooperation with aviation and electronic warfare. **Command and Control Warfare** consists in hitting and disrupting the work of selected elements of command post (brigade and division levels)(CP), command points (tracking, interfering, etc.) of reconnaissance and electronic warfare units. This task should be carried out continuously at all stages of the fight. For effective use, artillery fire should be coordinated with electronic interaction. **Suppression of Enemy Air Defense-** activity that neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive and/or disruptive means.

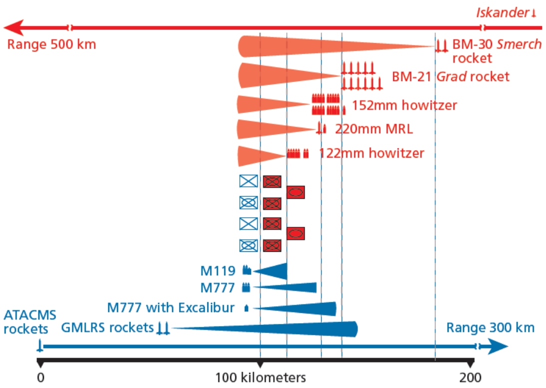
In summary, the four main roles of artillery on the modern battlefield can be identified:

- suppression of enemy fires;
- striking high-value targets (HVTs);
- breaking up enemy force concentrations;
- providing fire support to enable maneuver (Watling, 2019, p. 5).

Completing each task will facilitate the execution of consecutive tasks.

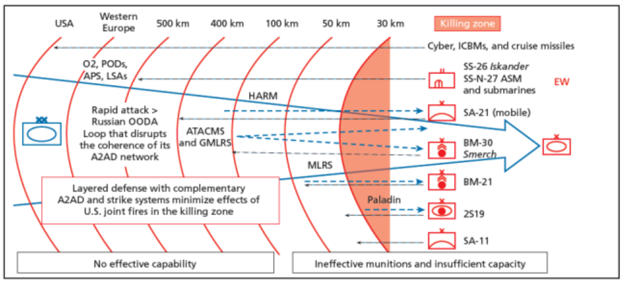
3. Modern artillery

The artillery of the U.S. and RF were compared in this article to present modern artillery capabilities. The U.S. Army field artillery has been recognized as one of the most powerful and relevant branches of the service since at least World War II. Field artillery played a major role during: the "hybrid" warfare period of Vietnam (1964–1972) and Operation Desert Storm of 1991. There was a very large amount of field artillery to support the armored units. By 2013, there was renewed interest in preparation for conventional combat. Offensive moves by Russia against Crimea and Ukraine, fear of Russian coercion against the Baltic states, an expanding Iranian military, and expeditiously growing Chinese military capabilities all contributed to the revived U.S. interest in conventional operations. Since 2017, the Russian Army has made significant advances in its artillery. Key Russian artillery capabilities include long-range multiple rocket launchers, such as the BM-30 Smerch, which can fire a wide variety of warheads up to 90 km. The SS-26 Iskander short-range ballistic missile also fires various warheads (including nuclear weapons) against targets at ranges of over 400 km. The Russian Army has deployed large numbers of cannons and rocket launchers at the brigade and battalion tactical group levels. When combined with a growing, multifaceted targeting and reconnaissance capability, Russian artillery is a tremendous potential opponent. Target acquisition systems are also improving. For example, the U.S. military has greatly expanded its use of unmanned aerial systems (UASs) since the start of Operation Enduring Freedom in 2001. Other countries have followed a similar course of action (Gordon IV, 2019, p. 14-15).



NOTES: MRL = multiple rocket launcher; ATACMS = Army Tactical Missile System; GMLRS = Guided Multiple Rocket Launch System.

Figure 1. U.S. Army Fires Compared with Russian Fires in a Baltics Scenario (Gordon IV, 2019, p. 15).



NOTES: ICBM = intercontinental ballistic missile; HARM = High-Speed Anti-Radar Missile; OODA = observe, orient, decide, and act; MLRS = Multiple Launch Rocket System; TACMS = Army Tactical Missile System.

Figure 2. Imbalance Between NATO and Russian Long-Range Fires Capabilities (Gordon IV, 2019, p. 42).

A simple comparison of the U.S. Army field artillery its counterpart systems in the Russian Army is shown in Figure 1. Russian artillery platforms (Iskander) have a greater range than that of the U.S.

Figure 2 shows that U.S. and NATO forces and assets can come under fire throughout the theater from Russian systems, such as the Iskander and the SS-N-27, with no system capable of responding beyond fixed-wing aircraft. This problem is compounded by Russian longrange IADS, built around the SA-21 (along with Russian airpower), that can block NATO from using its airpower in a decisive way early in the conflict. Russian rockets and artillery also outrange their NATO counterparts and thus can threaten NATO ground forces while protecting Russian forces from what could be decisive NATO close combat capabilities (Gordon IV, 2019, p. 41).

The following recommendations are presented to reduce disparities:

- increase the number of field artillery units that can deploy quickly to a crisis or that are located forward, where the fast arrival of allied forces is essential;
- improve the Army's ability to quickly get and utilize intelligence, surveillance, and reconnaissance (ISR) data from the other services;
- modernize the Army's cannon systems, particularly in terms of range and rate of fire;
- ensure that there is a timely and adequate replacement for the Army Tactical Cruise Missile System (ATACMS);
- improve Army ground forces target acquisition capabilities;
- improve the artillery's ability to provide fire support to allied and coalition partners;
- enhance the field artillery's electronic warfare (EW) and cyber resilience;
- reduce the artillery's vulnerability to enemy fires through reduced exposure to EW targeting, improved mobility, and use of camouflage and decoys;
- improve the survivability of artillery units against enemy indirect fire, airborne, and ground threats;
- emphasize major conventional opponents in field artillery, combined arms, and joint training exercises;
- continually assess technology trends that could improve the effectiveness of field artillery units (Gordon IV, 2019, p. 16-17).

4. Trends in increase artillery capability

Presently technological developments in artillery are incremental and slow. Nevertheless, some technological trends that are likely to have a transformative effect on the delivery of fire against ground targets can be mentioned. Based on analysis of the U.S. and RF artillery, four crucial trends can be indicated while acknowledging that the capabilities outlined in this article do not remove the value of unguided high explosives, and are transformative only when employed as part of a coherent concept of operations. The following trends should be considered:

- the increasing range of artillery systems;
- the maturation of active seeker munitions with sufficient fidelity to reliably strike ground targets;
- automated command and control (C2) systems able to decrease the complexity of kill chains;
- increasingly sophisticated Counter-Rocket, Artillery, Mortar (C-RAM) systems.

These capability trends induce fires capabilities in three critical ways:

- the probability of kill (PK) of fire missions is increasing, reducing the number of platforms needed to deliver significant effects;
- there is a growing tension between the need to manage munitions, and the speed of engagement, which is pulling C2 both down and up echelons;
- the battlefield is increasingly divided not so much by range, but by zones where fires outweigh protection, and vice versa (Watling, 2019, p. 17).

Increasing range. Modernly, 155-mm and 152-mm howitzers have reached ranges between 32km and 48km using base bleed, while MLRS systems have achieved 70–120-km ranges. Under test conditions, the artillery achieved even greater range (155-mm howitzers able to deliver rounds up to 70km (Keller, 2019)). By using gliding bombs (stand-off bombs), 120-mm mortars have extended their ranges from 5km to up to 16km (Watling, 2019, p. 17). In 2021, the U.S. Army will test the Precision Strike Missile (PrSM) at its maximum range of over 480 km (Freedberg, 2020). Across the world, the ranges of standard artillery systems are being pushed further and further. It should not be assumed that this trend will continue infinitely. With the use of conventional projectiles accuracy decrease as the range increases (especially at maximum ranges). It is estimated that ranges of artillery systems are likely to increase by 50–100%. The general increase in range will have a complex impact on the modern battlefield. Improvement will effect C2 and how maneuver elements will need to operate, and coordinate with their fires. The range of artillery is increasing while the speed of advance of maneuver formations does not. In effect the correlation between the range of fire systems and the reach of maneuver elements is being changed. A greater range means that batteries are less tied to brigade displacements during combat. It therefore becomes possible to provide support by artillery batteries to a greater number of independently maneuvering elements. This means that a gun line may be dispersed further to the rear, and operate as a centrally managed divisional fires group, but still provide support to each maneuver brigade. Thus, the command of the emplacement and fires plans of guns may be held for longer at a higher level. A further consequence of the increase in range is that whereas traditionally a brigade would receive fire support from the batteries assigned to support its operations, the increase in range enables a smaller number of guns in a divisional fires group to nevertheless bring a higher proportion of the group’s fire to bear in support of a specific maneuver brigade. A further significant effect of the increasing range of fires systems is its impact on sustainment operations (Watling, 2019, p. 18-19).

Multi-Sensor Active-Seeker Munitions. Most early precision weaponry contained guided munitions, brought on to target by a laser designator, or with the course corrected by an operator. The need for constant communication between the operator and projectile reduces the effective range or provides a single dependency that could be disrupted by opponent EW capabilities. These challenges are now being overcome with the miniaturization of computing and the integration of multi-sensor munitions, with the ability to autonomously seek targets. Inertial guidance is consistently able to bring munitions close enough for onboard sensors to begin course correction during the last phase. All single sensors have curtailments. Electro-optical sensors, for instance – presumably to offer the most accurate strikes – tend to struggle if visibility is limited below 700m. Millimetric radar seekers are able to pick out armored vehicles in dense terrain or poor visibility, but struggle to distinguish between a priority target, a not-priority target and the decoy beside it. In the meanwhile, camouflage materials are able to counter infrared seekers. The ability to integrate multiple targeting systems into a single munition has greatly increased the reliability, fidelity and accuracy of precision munitions, while computer processing has enabled munitions to autonomously course correct to deliver precision strikes. The develop and application of multi-sensor active-seeker munitions is increasing the lethality of a range of fires systems against dynamic targets. Munitions with multi-sensors reduce the number of rounds required to break up enemy force concentrations of vehicles or conduct counterbattery fire (Watling, 2019, p. 21-22). Another crucial path of development for multi-sensor active-seeker capabilities is small-target unmanned aerial vehicles (UAVs). There has been a great deal of hype regarding autonomous swarms of UAVs, and while such technologies may have some utility in spoofing radar systems, swarming technology is unlikely to be transformative in the delivery of fires (Davis, 2014, p.4). An additionally critical element of these systems is their capacity to act as loitering munitions to deny ground. The emplacement of such active-seeker munitions into identified corridors of adversary advance enables tactical units to canalize enemy forces and shape their movement, diverting them into kill zones for conventional artillery. The capabilities of Multi-Sensor Active-Seeker Munitions causes complications in the management of fires. If the range of conventional fires is enabling their management at higher echelons, the speed of engagement required to maximize the effects of active-seeker munitions forces the decision to employ fires as low as possible. The point is that an active-seeker only functions if there is a target within the area that it can scan. Either the friendly maneuver element calling for fire must fix the target, potentially exposing themselves to comparable effects, or the time between the call for effect and its delivery must be reduced as much as possible. Units in contact with enemy which will be calling for fire will tend to calling for the effect with the highest PK to engage any and all available targets. As a result of a limited amount of active-seeker munitions available this will deplete ammunition supplies. Ensuring a quick enough kill chain therefore demands the development of appropriate supportive C2 processes (Watling, 2019, p. 23-24).

Automated command and control (C2). The concept of a unified and complete battlespace management system enabling the three-dimensional visualization of the battlespace in real time is important in military nowadays. It is questionable that such a system becoming feasible. However, the drive towards advanced battlespace management is creating an increasingly diverse range of methods for fusing disparate sensor feeds. The most important developments are systems designated to translate separate and distinct data sets into a single language, enabling different types of data to be compared. These capabilities have important implications for artillery systems by reshaping kill chains, and the decision point for the application of fires. The quantity of sensor data is still to expand, but in a high-intensity conflict the capacity to process it will be limited, and the viability of having a large targeting cell supporting the high number of synchronic operations involved is doubtful. Moreover, the need to transfer large quantities of data to centralized headquarters for it to be processed produces a slow kill chain. The time lag created by the transmission and processing of data also makes keeping track of dynamic targets difficult without a constant exchange between sensor and shooter, which must be vulnerable to interference. The link also creates a durable signature, enabling foes to locate and fire upon command infrastructure. System operation can be presented as follows: a sensor has located an enemy truck-mounted command vehicle. Rather than passing its coordinates, the observer takes a picture, marking one of the pixels from the target, and transmits this image in a single explosion to the fires CP. At the CP, the image is received and fused with other images from other planes, most importantly a satellite or aerial image, which allows the target pixel in the vertical plane to be translated into a point on a map. The fusion system – using computer vision – also notes that the target is specific type of equipment and attaches the electro-optical, infrared and radar signature of this target to the data packet containing the target's coordinates. This is transferred to a fire platform, and the data is ingested by the munition, which is launched to the area containing the vehicle. Having reached the area, the sensors in the missile warhead first identify the pixel from the original photograph, and then scan to see whether the target still resembles the command vehicle. If the signature has changed, the missile could then scan the area to see where the target had moved to, and course correct (Watling, 2019, p. 25).

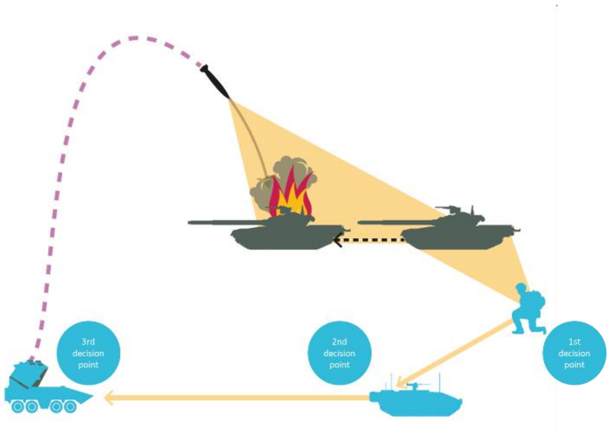


Figure 3. Kill Chain with decision points. Own work basis on Watling, 2019, p. 26.

The system described above is indicative of a C2 architecture for fires that is probably to become increasingly viable and widespread. Its application has the effect of increasing speed of the targeting cycle, while reducing the amount of calculations required by fire controllers. Such a system has three decision points: the sensor operator deciding to call for fires; the fires CP which must assess whether the target selected is worth the ammunition necessary to destroy it; and the fire platform commander, who must assess whether launching would expose their platform to risk. In general, as the supply of ammunition is an operational affair, command would rest with the CP, but the need to ensure the fastest possible speed of engagement would encourage pushing control to the sensor operator (Watling, 2019, p. 26).

C-RAM. Counter-Rocket, Artillery, Mortar system was developed early during Operation Iraqi Freedom/Enduring Freedom in order to protect ground forces and forward operating bases from the threat of rockets, artillery, and mortars. C-RAM systems must be coordinated through airspace control means and be integrated in the NATO Integrated Air Defense System (NATINAMDS) architecture. The C-RAM serves as defense against artillery, and in this context, its development sets new directions for field artillery. C-RAM is made up of a variety of systems which provide the ability to sense, warn, respond, intercept, command and control, shape, and protect deployed forces. C-RAM components include the Forward Area Air Defense Command and Control (FAAD C2), Land-based Phalanx Weapon Systems (LPWS), Lightweight Counter Mortar Radars (LCMR), Firefinder radars, Kaband Multi-Function Radio Frequency Systems (MFRFS), Air and Missile Defense Workstation (AMDWS), and several other components that contribute to system intercept and communications (*Counter-Rocket,* 2018). The development of high-accuracy search-and-track radar has reached the point that it can direct rotary cannon to accurately and consistently engage mortars and artillery rounds, causing them to detonate in flight. The capacity to hard-kill incoming artillery, providing area defense against indirect fires, is meaningful. The location of such systems can provide a final and strong layer of point defense for critical areas. However, these systems speedily deplete their ammunition, can be saturated and are expensive. Moreover, they are easily to trace due to their radar emission. It should be noted that as munitions are increasingly dependent on sophisticated sensors to locate their targets, so too do they become potential victims of decoys. The ability to absorb precision strikes by setting up dummy systems has the potential to notably increase the amount of munitions needed to destroy a set of targets. Decoys, however, are large, heavy, and generally take time to assemble, so while they may be used to protect HVTs, they are less likely to provide protection to maneuvering tactical platforms. The one exception is against EW directed fires, as it is now possible for very small emitters to imitate the signature of battlegroup headquarters and other HVTs (Watling, 2019, p. 29-31). Further work on the development of this technology is necessary.

5. Summary

This work has tried to outline the critical trends in the development of the next generation artillery systems. They include:

- the increase in range of fires systems, potentially doubling the range of most precision ammunition;
- the development and dissemination of multi-sensor active-seeker munitions;
- the capacity to link various information to advance the targeting process and centralize control of fires;
- the development C-RAM capable of creating protected nodes from artillery.

Despite this technological progression, however, it is understandable that conventional ammunition have a crucial role on the future battlefield in view of the cost and limited stockpiles of precision-guided munitions that forces can maintain. The future battlefield created by new trends will be packed with the growing number of sensors. They will give the ability to aggregate and fuse their data rapidly. As a result of the enlargement in the range of systems with a high PK, enabling the delivery of a high amount of projectiles onto maneuvering force concentrations on the future battlefield will be a much smaller force density. Field artillery will be a crucial component of the future battlefield. The next phase of development will be the implementation of an automatic C2 system for autonomous unmanned fire platforms with using UAVs.

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