The impact of war generations on spatial environment and military resistance challenges in urban planning

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Abstract. The subject of scientific study is the role of generations of war in the development of architecture according to the military classification. War-resistant architecture has evolved with the changing nature of warfare and advances in military technologies. These challenges remain relevant even today. Through a multi-content analysis of scientific literature, this research observes the impact of wars on urban development activities. Analysing the historical correlation between urban development and military progress can provide insight into the evolution of military-resistant architecture. The results of this study can contribute to the development of future urban planning solutions to meet both current and future military challenges. As a part of the analysis, a table is presented, which summarizes the relevant parallels of the classification of the generations of wars, used weapons, the type of conflict, and urban defence.

1 Introduction

Throughout history, military-resistant architecture has often been a reflection of the prevailing military technologies of the time, shaped by significant historical events like wars and territorial conquests. In the context of "The Impact of War on the Meaning of Architecture in Kuwait," the interplay between war and architecture emerges as a crucial consideration. The need to repel enemy advances played a key role in the creation of defensive structures in the ancient urban environment. In fact, war has always been a major source of destruction of buildings, cities, and cause of casualties [1].

Military architects and theoreticians have studied the problem of resistance to settlements and the key role of fortifications in war. They presented scientific theories corresponding to their time. The principle of “firmitas", denoting structural strength and durability, occupies a paramount position within the Vitruvian Triad, a foundational architectural concept. This emphasis was an imperative arising from the demands of the times. Its significance has transcended historical eras, remaining a vital necessity regardless of the era under consideration [2].

The 20th-century French philosopher and architecture critic Paul Virilio described fortification as the first primary factor in shaping cities and organizing space [3]. A strategy of war to destroy social identity, obliterate culture, and assert territorial claims, have been military attacks on architecture and historical environments [4].

Studying changes in the spatial environment is a critical aspect of modern urbanism theory. In the case of military operations, the urban area becomes an object of risks and threats [5]. Territorial defence requires a set of systemic measurements and tools aimed at creating a favourable spatial environment for the lively hood. After all, war can have profound consequences on the social structure and life of communities affected by military operations. Therefore, it is necessary to respond urgently and seriously to ensure the security of settlements in modern conflicts [6]. In the wars of the newest generation of the 21st century, the use of long-range high-precision weapons, aviation, and the nature of irregular tactical operations characteristic of modern hybrid wars create new security challenges. Although territorial defence mainly focuses on the use of military methods, it is still very important to consider how the organization of the spatial environment can limit military capabilities. Therefore, a thorough investigation and assessment of the urban environment is essential in terms of effectiveness in planning military operations in different historical periods. It is necessary to examine the constituent elements of the spatial environment, the role of generations of wars in the shaping of these elements, and the possibilities of adaptation of the settlement to the current war requirements.

2 Methodology

The research methodology revolves analysis of the generations of wars and the corresponding urban development features according to the principle of historicity, focusing on the military strategies, patterns, threats, and risks assessment specific to each period. It is a comprehensive historical analysis of urban planning and military theory, an assessment that aims to reveal the connections between these disciplines. This analysis includes various sources such as scientific articles, monographs, and papers. The aim is to understand what role specific urban and architectural elements played in defensive strategies.

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3 RESULTS AND DISCUSSION

3.1 Characteristics of the spatial environment

In the case of war, a radical transformation and reinterpretation of the spatial environment take place [5]. The term "spatial environment" refers to the physical and man-made environment in which people live. At the same time, urban terrain is a combination of horizontal, vertical, internal, and external dimensions superimposed on the natural landscape [7]. In the horizontal dimension, urban areas refer to the following dimensions:

Surface areas refer to external surface areas such as highways, streets, sidewalks, fields and parks, parking lots, and airports. These often become primary targets of attack.

Super surface areas include the inter-floor coverings and roofs of buildings, stadiums, towers, or other vertical structures. They can provide cover and camouflage, and limit or increase the visibility of the environment.

Underground areas are located below surface level. They can be hiding places or evacuation routes. Underground spaces include subways, tunnels, sewers, drainage systems, basements, civil defence shelters, and other systems. In ancient cities, these may have included hand-dug tunnels and catacombs. Both the attacker and the defender can use underground areas to surprise the opponent. The effectiveness of implementation depends on their design methods. Urban areas should not look like isolated islands, but all connected to surrounding settlements and areas [8].

The evolution of the spatial environment and its relation to the development of generations of wars will provide valuable insights into the historical progression of human conflicts, and the specifics of the use of spatial dimensions.

3.2 The generations of war and the organization of the spatial environment

There are different perspectives across the world about the classification of warfare generations. For each generation of war, according to the used weapon and military purpose, spatial possibilities of combat operations, civilizational characteristics, and the corresponding urban planning features of the spatial environment of the settlements were also changed and adapted. Moreover, each generation reflects changes in the nature of war and the technologies used to wage it. The article embraces the classification put forth by military theoretician A. Hovhannisyan as its foundational framework [9].

3.2.1 The first-generation

The first generation of war spans the pre-feudal period, from ancient civilizations to the Middle Ages. It was characterized by the predominant use of manpower and cold weapons, with the use of ranged combat, melee combat, and defensive measures. The organization of a safe spatial environment implied the use of high positions and inaccessibility. The complex terrain and traps on the way did not allow the enemy's manpower to climb to the top of the rock to capture it. One such example was the use of thick trees and simple caves on high cliffs. As societies shifted to a more sedentary lifestyle, building castles became important. During this period, fortresses had a two-part plan structure, consisting of a fortress and a settlement. In order to protect settlements against horizontal attacks and invasion there were vertical barriers in vulnerable areas [10]. Fortress-settlements and Castles had a strategic position as part of the general spatial strategic system. These structures had a certain location and distance from each other, which made it possible to provide light signal communication, control the terrain and limit the movement of enemy forces [11].

3.2.2 The second generation

In the second generation, gunpowder and firearms appeared which completely changed the range and scale of military operations. Artillery provided long-range firepower and the ability to breach fortifications, changing the dynamics of battles and sieges.

Due to the nature of the feudal social system, changes took place in urban planning. The settlements changed to a three-part plan structure consisting of the citadel, city, and suburbs, the citadel acting as a strategic unit, and the city as the social and activity centre of the settlement. Defensive walls, making up the fortified part of the city, surrounded the citadel and the fortress [10]. The introduction of devastating siege machines such as battering rams, siege towers, and catapults created new challenges. The main objective of the besieged was to prevent the approach of these siege vehicles towards the walls. At the corners of the mentioned structures, towers were built to reduce this problem, [12]. The maximum distance between the towers depended on the range of the bow. In front of the curtain walls, they created puddles and earth barriers [11]. It allowed archers to target approaching enemies from different vantage points.

The use of openings in early medieval fortifications was limited. With the development of archery and firearms, the number of loopholes and architectural solutions increased significantly. The main and sometimes secondary city curtain walls of the developed Middle Ages had several layers, consisting of inner and outer lines [11].

The castle should be designed to withstand not only direct attacks but also indirect attacks such as artillery bombardment [3]. Instead of the vertical profile of the curtain wall, the lower part of the wall was given a very pronounced slope. The projectiles fell from above and hit the enemy by reflecting on the wall. One of the defensive elements of the castles was the double-sloped cornices built on the walls, which protruded from each side and would deflect the direction of the bomb by reflecting it [13]. One of the main characteristics of settlements was dense construction and communication

of adjacent buildings through holes and openings. In case of perceived danger, this made it possible to exchange things, quickly inform each other, and move from one building to another [14].

3.2.3 The third generation

The third generation included the Industrial stage of society. This era witnessed conflicts such as Napoleonic Wars (1790-1814) and the World Wars.

Comparing the battles of units armed with spears, arrows, and cavalry to battles with gunpowder, tanks, armour-piercing explosive devices, and bombs, they are very different in terms of tactics, and destructive effects. Latter can turn the urban environment into piles of smoking dust [15]. The strikes were carried out with the same power, both on the front line and with tactical and operational depth.

According to Viollet-le-Duc, it was time for a change in military architecture. Traditional castles and city curtain walls were strengthened and upgraded to withstand artillery bombardment. The fortifications of the late 19th century had become heavy but ineffective, leading to the use of new construction methods: temporary structures, lines of bunkers, camouflage super surfaces and ditches. Castles were useful until the end of the 19th century, when the main defence problem was not the high position, but the camouflage. Thus, the role of trenches and underground infrastructure in the design increases. The walls and fortifications of the cities could not serve as a reliable defence against the invasion of the enemy, regardless of their strength [3].

During World War First, when the bombing of settlements became massive and the idea of a safe rear disappeared, in 1915 the concept of "civil defence" is put into use for the first time. Here, it was realized that it is impossible to carry out defence measures exclusively with the forces of the active army. The primary task was to create shelters for the protection of the population, and for this purpose, subway stations, underground passages, and other public structures began to be used. For example, windows and other openings in buildings were often covered with sandbags to provide additional protection from aerial bomb blasts and flying debris. Furthermore, during air raids, it was recommended to turn off street lamps to minimize visibility for enemy aircraft [16]. The implementation of civil defence measures marked an important shift in war strategy, realizing the importance of protecting the civilian population from air attacks. Airspace itself began to present new threats, which led to a rethinking of military-resistant strategies. Unlike previous conflicts, where defence focused primarily on defending against ground attacks, the emergence of air and space capabilities required a three-dimensional approach to defence. Defensive structures such as fortresses or curtain walls designed to prevent land attacks are losing their importance. This meant that the traditional defence structures designed to withstand ground attacks were losing their effectiveness.

Along with increasing the power and range of the means of attack, the role of aviation, in this case, becomes decisive, forcing one to search for shelters and protected places even for deep rear objects. Aerial bombardment leads to not only the destruction of buildings and infrastructures but to the mass casualties of the civilian population, and the destruction of historical-architectural monuments, in extreme cases, the urban environment can turn into ruins [5].

Tanks and airplanes played a significant role in World War Second. There were used Different types of shelters to protect civilians during air raids. Among the famous projects were the towers designed by the German engineer Leo Winkel. These towers often called Winkel Towers, sheltered civilians during bombardments. They were aboveground structures using reinforced concrete and usually had thick walls to withstand the impact of bombs and other explosives [17].

The use of air power created significant challenges for concealing buildings and structures of historical value. There were used various methods to camouflage and protect these structures from detection and destruction during air raids. One common technique was to paint walls and roofs in different special colours to blend in with the surroundings. Another method involved covering buildings with sandbags, which was both a protective measure and a way to hide the structures. Sandbags provided additional protection from blast effect and flying debris while making it difficult for pilots to distinguish buildings from the surrounding landscape. There have also been used timber and earthen structures to create false facades or walls around historic buildings. These temporary structures helped to mask the true appearance of the buildings and made it more difficult for pilots to accurately identify and target them [18].

The construction of underground shelters became increasingly important for both military and civilian purposes. These shelters were often constructed of thick concrete and steel to protect against air raids. In some cases, earthen roofs were used to further increase shelter concealment.

3.2.4 The fourth generation (1945-1982)

The main factors characteristic of fourth-generation warfare were atomic energy and jet propulsion, radio-electronic systems, and electronic local control systems. Warfare theatres and communication lines became larger, and missiles that could hit the entire area of the opponent replaced the previous fireworks. [9]. The advent of modern technologies has significantly enhanced the ability to identify the location of trenches, buildings, and infrastructures. Therefore, in addition to masking, it was necessary to apply other technical solutions to reduce the damage caused by stab wounds. However, in the period following World War II, particularly in Europe, the focus on military resistance in architectural planning declined. It can be attributed to several factors, including the absence of large-scale military operations in the region and the development of

air defence systems. It should be noted that this situation is changing in the Russian-Ukrainian war. Countermeasures may vary depending on the specific geopolitical context and perceived threats in a particular region. Approaches to resilience and architectural planning may differ significantly in areas where conflict is more common or where the risk of aggression is higher.

3.2.5 The fifth generation

The main advantages of the fifth generation were automatic control systems, satellite communication, interconnected, and joint use of high-precision weapons. Information influence became decisive. Irregular combat operations began to appear more often. This led to an increase in the role of urban battles [9].

The increasing use of air and space assets has emphasized the need for comprehensive territorial defence measures. Urban warfare replaces siege warfare. The physical location of cities has changed over time. In the past, the castles that protected cities were strong, but the internal construction of houses and buildings was not. Along with the development of the technologies of the time, architectural solutions have changed: the curtain walls have disappeared, but the structures inside the settlement have remained vulnerable[15].

Residential buildings, schools, churches, streets, and parks can lose their everyday functions and be adapted for various military purposes. They can become defence structures, military warehouses, military units, hospitals, combat positions, and observation posts [5].

3.2.6 Sixth generation (Modern period)

This generation is the period of digital, artificial intelligence, and wide communication networks. This is the war of electromagnetic energy applications, lasers, and other energy sources. There will be used Self-guided missile platforms and nanotechnology in this war. The deployment of modern weaponry causes serious damage to infrastructure and disrupts the normal functioning of the urban environment.

Since the volume of built-up urban areas has increased incomparably compared to previous eras, the current problems facing urban development are very different. Concealment becomes almost impossible; the main problem here is reducing possible damages, and adapting the spatial environment to possible war scenarios. In urban areas, the density, structure, and application of different dimensions of the man-made physical terrain allow for the rapid use or shaping of the environment to further strengthen protective measures. These plans should be implemented to limit the effectiveness of the attacker's military equipment capabilities such as visibility, and air strike capabilities, maximize the unpredictability of the area and mitigate potential damage to buildings and structures [19]. In the urban environment, changes in terrain often require a change in the types of troops used [20]. Urban terrain creates difficulties for heavily armoured vehicles and tanks. Therefore, the use of rifle and mountain rifle troops becomes more favourable. These troops are typically equipped with light weapons and are trained to operate in complex and restrictive urban environments.

3.3 Adaptation of a City to the Modern Warfare Imperatives

The increasing role of urban warfare and irregular warfare in the 21st century presents unique challenges for the safe organization of the spatial environment. Current considerations on territorial defence are based on the belief that the defence capability of a state depends not only on the ability of the armed forces to repel military aggression but also on the protection of the rear and the organization of resistance within the country. This problem should be solved also within the spatial planning system of the settlement. It requires a comprehensive study of urban planning, architecture, military measurements and other spheres of livelihood activities in the same context [21].

All this proves that the importance of urban planning in border settlements is great both during the normal livelihood of people in peaceful conditions and during the danger of possible military operations when both military objects and settlements with a civilian population are military targets. In that sense, there are main elements of the spatial environment, which have a vital sign and therefore require military resistance.

3.3.1 Physical features of the site

The first and main condition for the assessment of military resistance in urban areas is the location of the building, construction, or other type of objects. All the characteristics of the landscape, combined with man-made construction, lead to the creation of a complex system, which greatly affects the increase of military resistance [22].

3.3.2 Construction features

From the point of view of increasing the military resistance to settlements, one of the most important issues is the density of construction of the territory. The surface area of damage resulting from a hit from even a low-powered military weapon used by the enemy is directly related to the density of the built-up area. The higher the building density, the greater the surface area and volume of damage caused by a single shelling or bombing. Targeting is difficult in urbanized terrain because the defending party has many covered and concealed positions and movement paths [23]. They limit visual observation and impair aviation application capabilities [23].

3.3.3 Communication and evacuation routes

Spatial planning should provide for dead zones and impassable transit lanes to prevent the enemy's advance [24]. The military resistance of these elements should be considered in relation to all spatial dimensions.

Attached is a table that summarizes the relevant parallels of the classification of the generations of wars, the weapons used, the conflicting associations and urban defence (Table 1).

3. Conclusion

In the historical-geographical conditions, when military operations remained in the ground area, the fortified cities scattered in the physical space were the borders preventing the invasion of the enemy. Urban planning had to adapt to the changing military landscape and incorporate elements that could withstand attacks from afar. This led to the use of fortifications, taking into account factors such as gun range, tactical considerations, and the need for more complex defensive structures. With the improvement of military equipment, the challenges faced by the current urban development activities are even more complicated, limited only to the reduction of possible damages.

Through the observed parallels, the following conclusions were drawn:

Table 1. Parallels in the classification of generations of wars, weapons used, types of conflict and urban defence.

CLASSIFICATION OF WAR	WEAPON TYPE	TYPE OF CONFLICT	URBAN PROTECTION MEASURES
First generation. Before feudalism (up to the 5th century)	Cold armour, manpower	Melee combat, infantry, and cavalry	**High position, inaccessibility, caves, vertical defences, fortifications,** Thick trees, rocks, underground tunnels, caves, mounds, single-line curtain walls, double and hidden entrances, two-part plan structures of cities, loopholes
Second generation. Between Feudalism and Industrial Revolution, 5-18th century.	Gunpowder, firearms, artillery, manpower	Melee, infantry, and cavalry, trench warfare	**High position, inaccessibility, caves, forts, vertical defence** Three-part plan structure of cities, secret passages, towers, double curtain walls, machicolations, loopholes, double entrances, movable ladders, watery ditches, movable bridges, donjon, ricochets, communication through openings, bastions
Third generation. Industrial age. From the 18th century to 1945	Internal combustion engines, automatic weapons, heavy artillery	Total battle, position trench	**Inaccessibility, concealment, fortifications, vertical and horizontal defences, underground architecture,** Barriers, trenches, basements, use of opaque material, sandbags, reinforced concrete underground shelters, mimicry of structures, earthen and green super surfaces [19]
Fourth generation After the World War 2. (1945-1982)	Long-range automatic and reactive weapons, ground forces, tanks, aviation, navy	Military operations on all fronts	**Camouflage, vertical and horizontal protection** Construction of reinforced concrete and steel underground and above-ground shelters, bunkers, trenches, cellars
Fifth generation Since the 1982 Lebanon War.	The predominance of air attack and precision strike means,	Battles of strategic depth, scale, and character.	**Camouflage, vertical and horizontal protection** Reinforced concrete and steel underground shelters, bunkers, trenches, buildings and super surfaces with armoured materials,
Sixth generation Modern period	Decentralized management and use of irregular forces,	Non-contact war on a strategic scale	**Vertical and horizontal protection** Keeping distances, reinforced concrete shelters, use of independent sections, buildings with armoured materials

- In the case of the first and second-generation classification, wars were mainly conducted in the horizontal plane, so the use of vertical landscapes, caves, then walls, and towers provided an adequate level of protection.
- In the third-generation war, the operational depth, the range of the weapons used, and the impact of damage increase. Thus, with the elimination of the safe rear, there is a need to protect the rear settlements as well; apart from the direct military contact line. The result was the creation of the concept of "civil defence" and the following urban development measures.
- In the context of fourth and fifth-generation wars, with the use of anti-aircraft defence, the defence system was focused mainly on military forces, with a decreased emphasis on the development of architectural science in this field. It was also a consequence of the absence of large-scale wars after the Third Generation War. The use of air power completely changed the nature of warfare, including all spatial dimensions in warfare. Therefore, the protection of settlements from air attacks is also a defence problem, that is, the possibility of concealment.
- Based on the security challenges in the 21st century, with the increasing importance of urban warfare, where military operations include settlements, there is a strong need to develop new urban planning concepts, taking into account the characteristics of warfare of both current and future generations. Therefore, architecture as a science should develop in parallel with the military sphere and become an integral part of territorial defence. As a result of further studies, new solutions and principles are expected to be discovered.

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