

# **ASSESSING THE IMPACT OF WARTIME CONDITIONS ON THE LAND SURVEYING INDUSTRY IN UKRAINE: ADAPTATION, CHALLENGES, AND RECOVERY STRATEGIES**

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## **Abstract**

This article examines the impact of the Russian federation's full-scale aggression in Ukraine on the market of land surveying and topographic-geodetic services. The study found that the market for land surveying services decreased by 60-70% due to restrictions in the functioning of the land cadastral system, the introduction of the permit procedure for field geodetic works, and the adaptation of procedures for granting land to citizens during wartime conditions. Technological limitations, such as the use of GNSS networks at the beginning of the war, also played a role in the decline of the industry. The article highlights the prospective needs for land surveying work for post-war reconstruction, including accounting for war damage and mapping affected territories, spatial planning for affected communities, infrastructure restoration, and land reclamation in areas where hostilities took place. The article provides insights into the challenges and opportunities faced by the land surveying industry in Ukraine during wartime conditions and emphasizes the importance of adopting appropriate strategies for recovery and growth. It is shown that despite the war, the development of the industry depends on further digitalization, improvement of the cadastral system, gradual liberalization of access to cadastral geodata, the introduction of special rules for regulating the activities of the surveyor in the territories where hostilities were fought.

Key words: land surveying, geodetic works, Ukraine, wartime, land cadaster.

## **Introduction**

On Thursday, February 24, 2022, at 3:40 a.m., the third stage of the Russian-Ukrainian war, initiated by Russia in 2014, began with full-scale military aggression against Ukraine. This escalation followed a long-term build-up of Russian troops along Ukraine's borders with Russia and Belarus since November 2021, culminating in the "recognition" of terrorist organizations on Ukrainian territory by Russian authorities on February 21, 2022. As part of this military campaign, missile strikes were launched throughout Ukraine, and Russian troops invaded various regions, including Kyiv, Kharkiv, Kherson, Chernihiv, and Sumy, entering from Russia, Belarus, and the temporarily occupied Crimea. In addition to Russia, Belarus also actively participated in the war against Ukraine, providing territory for launching missile strikes, deploying combat aircraft for missile and bomb attacks, and providing troop support.

The wide-ranging military aggression has had profound consequences on multiple aspects of Ukrainian society, including its economy. Among the sectors most affected by the ongoing conflict is the land surveying, topographical and geodetic industry. This article aims to examine the impact of the full-scale Russian aggression on the state of land surveying in Ukraine, exploring the challenges faced by professionals in the field, the disruption of essential services, and the potential long-term consequences for both the industry and the country's geospatial infrastructure.

Researching the key challenges faced by the land surveying industry of Ukraine in wartime conditions is essential for several reasons. A comprehensive understanding of the impact of the war on this crucial sector allows policymakers, industry professionals, and stakeholders to make informed decisions and develop effective strategies to address the challenges.

This research aims to find the strategy to minimize the negative impacts on land surveying, topographic and geodetic activities, and ultimately, the Ukrainian economy and infrastructure. Understanding the challenges faced by land surveyors, geodesists, and land appraisers is vital for developing policies and support mechanisms to protect the workforce, retain professional expertise, and ensure the continuity of essential services. Furthermore, identifying and addressing these challenges enables stakeholders to develop and implement recovery plans that support the industry's restoration and growth once the conflict has ended, contributing to the overall rebuilding and development of Ukraine's economy and infrastructure.

## Methodology of research and materials

To assess the impact of the full-scale Russian aggression on the land surveying industry in Ukraine, our research methodology relied on the analysis of public data provided by the State Service of Ukraine for Geodesy, Cartography and Cadaster, specifically the "Portal of Electronic Services of the State Land Cadaster."<sup>2</sup> This portal offers monthly statistics on the number of cadastral administrative services, including land plot registration, from 2015 to the present. To estimate the number of land surveyors, geodesists, and land appraisers in the regions of Ukraine where hostilities were fought or temporary occupation persists, we utilized previous studies conducted by the authors [1]. These studies were based on official public data from the State Register of Certified Land Surveyors, the State Register of Certified Geodesists, and the State Register of Appraisers of Expert Monetary Valuation of Land. In addition, we analyzed changes in the regulatory framework of Ukraine pertaining to the adaptation of the land management system, land cadaster, topographic and geodetic activities, and land assessment under wartime conditions. This analysis was based on official documents published in the "Legislation of Ukraine"<sup>3</sup> database of the Parliament of Ukraine. Through this comprehensive research methodology, we aimed to gain a thorough understanding of the challenges faced by the land surveying industry in Ukraine during the ongoing conflict, as well as the potential long-term consequences and strategies for adaptation and recovery.

## Discussions and results

The land surveying industry is crucial for Ukraine, as well as for any European country, as it plays a pivotal role in guaranteeing rights to land and other real estate, ensuring the functioning of relevant real estate markets, spatial planning, environment protection etc. These functions are essential for fostering economic growth, maintaining social stability, and promoting sustainable development. Wartime, however, presents a difficult test for land surveyors, geodesists, and appraisers, as their industries primarily serve economic growth, while war leads to a sharp decline in economic activity within a country. This highlights the importance of understanding and addressing the challenges faced by these professionals during conflict to support their resilience and the continuity of their vital services.

We can highlight the following key challenges for the land surveying industry of Ukraine in wartime conditions:

- Reduction in demand for land surveying and topographic-geodetic works, because due to the uncertainty and risks of wartime, investment activity is reduced, construction and development projects are frozen, the state and local communities are almost completely reorienting their budgets to defense and crisis response.
- Impossibility of performing works (including previously contracted ones) due to risks to the personal safety and life of surveyors in temporarily occupied territories, in zones of active hostilities, as well as due to military restrictions or the risk of the presence of explosive objects.
- The introduction of new regulatory rules and restrictions for business during the war, which makes it impossible for land surveying and geodetic companies to operate (permissive procedure for the execution of field surveys, stoppage or limited functioning of the IT systems of the State Land Cadaster and the State Register of Rights to Immovable Property, etc.).
- Temporary or irreversible loss to the industry of highly qualified specialists due to their forced movement within the country and abroad, mobilization to the Armed Forces, repurposing due to economic instability and the inability to receive a stable income working in a specialty.
- Technological restrictions for the performance of work (restriction or complete ban on the use of airspace for UAVs, complications for the use of GNSS equipment in the conditions of the operation of electronic warfare, additional restrictions on the use of GNSS networks, etc.).

Since the Russian invasion was accompanied by a large-scale cyber-attack on the IT systems of the Ukrainian authorities, in the very first days of the war, the administrators physically disabled the servers that hosted state information resources, registers, cadasters (including the State Land Cadaster, the State Register of Real Property Rights etc.). Physical data protection became the main priority.

Captured Russian military documents showed that they often used outdated topographic maps, the relevance of which corresponded to the 1980s. Thus, an important task was to prevent the aggressor

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<sup>2</sup> URL: <https://e.land.gov.ua/statistics/>

<sup>3</sup> URL: <https://zakon.rada.gov.ua/laws/main/>

from accessing the current geospatial data of Ukraine published on the public cadastral map, the geoportal of the National Infrastructure of Geospatial Data, the geoportals of urban planning cadastres, etc. Obviously, access to modern geospatial data could improve an aggressor's military planning and missile strikes. Therefore, all public geoportals in Ukraine and geodata access services were disabled.

On February 25, 2022, a Russian cruise missile hit a new apartment building in Kyiv on Valery Lobanovsky Avenue. Based on the direction of the missile, the possible target was the data processing center of the State Land Cadaster Center, which stores about 4.6 TB of data, including:

- information of the State Land Cadaster (registration of plots, land use restrictions, administrative boundaries, cartographic basis, etc.);
- scanned land surveying documentation;
- scanned land title documents issued before 2013;
- orthophoto plans, Earth remote sensing materials.



Fig. 1. An apartment building on Valery Lobanovsky Avenue, 6A, located near the State Land Cadastre Centre, on February 25, 2022, a few minutes after it was hit by a Russian cruise missile (photo from the Telegram channel of Kyiv Mayor Vitaliy Klitschko).

After that, in February-March 2022, with the help of the Armed Forces, the data storages with the information of the State Land Cadaster server, and later the server equipment itself, were evacuated from Kyiv to one of the western regions of Ukraine. The further chronology of measures to preserve and restore the functioning of the State Land Cadaster in wartime conditions was as follows:

- April 2022 – development of options for restoring the functioning of the State Land Cadaster (in one of the western regions of Ukraine; in one of the EU countries; transfer of the server to a cloud service, etc.), development of a regulatory framework for temporary "paper" registration of plots;
- May 2022 – after the liberation of the north of Ukraine and the improvement of the security situation in Kyiv, the server equipment was returned to Kyiv, the functioning of the system was restored, a "cold" backup copy was created on cloud services;
- May-June 2022 – adoption of legislation and by-laws on the functioning of the State Land Cadaster in wartime, limited restoration of the system, connection of users
- September 2022 – April 2023 – introduction of new functional capabilities of the cadastral system (registration of functional zones in spatial planning, electronic statements on the tax monetary valuation of land, registration of community territory boundaries, etc.);
- December 2022 – February 2023 – audit of software, technical and technological condition of server equipment;

- April 2023 – establishment of a regulatory requirement for the reservation of State Land Cadaster data in the National Center for Reservation of State Information Resources (including the transfer of backup copies of data for storage to foreign diplomatic institutions of Ukraine).

The practice of the first months of the war showed that the services of the State Land Cadaster are extremely necessary and important even in wartime conditions. Cadastral data is necessary for the public land management, the urgent placement and repair of infrastructure facilities, the search for land plots for the evacuation of enterprises from the combat zone, and the construction of housing for displaced persons etc. Therefore, despite the suspension of the IT systems of the State Land Cadaster in the first days of the war and the uncertainty regarding the possibility of restoring their functioning, the development of alternative decentralized "semi-paper" land rights registration systems that could function in the conditions of non-working data processing centers began almost immediately. Therefore, the Law of Ukraine dated March 24, 2022 No. 2145-IX introduced Books of Land Ownership and Land Use Registration under Martial Law, which were kept in paper and electronic forms in district military administrations. These books allowed the registration and transfer of agricultural land rights as early as April 2022. The electronic version of the land survey documentation (certified by the electronic digital signature of the land surveyor) served as an appendix to the title document, if necessary.

The Law of Ukraine dated May 12, 2022 No. 2247-IX made it possible to systematically adapt the land legislation of Ukraine to functioning under martial law. The key novelties that unblocked land surveying work include: restoration of the limited functioning of the State Land Cadaster (without a public cadastral map and with special requirements for state cadastral registrars; permanent disconnection of services in the temporarily occupied territory and in the combat zone); the possibility of quickly providing public land for the most urgent needs without electronic land auctions and approval procedures, etc.

In the first months of the war, intensive anti-sabotage activities were carried out, so in the period from April to November 2022, a permissive procedure for carrying out field geodetic works was legally introduced. Land surveyors and geodesists conducting field surveys using geodetic equipment, as well as wishing to receive cadastral data, had to obtain a special permit from the Security Service of Ukraine. Such permits were issued to land surveyors and geodesists who passed counter-reconnaissance inspection.

In fact, since May 2022, it has become possible to carry out land surveying in Ukraine, but it is practically impossible on 21% of the territory of Ukraine, which is temporarily occupied or where hostilities took place and the liberated territory may be contaminated with unexploded ordnance, which poses a threat to the life of the surveyor (Fig. 2, 3).

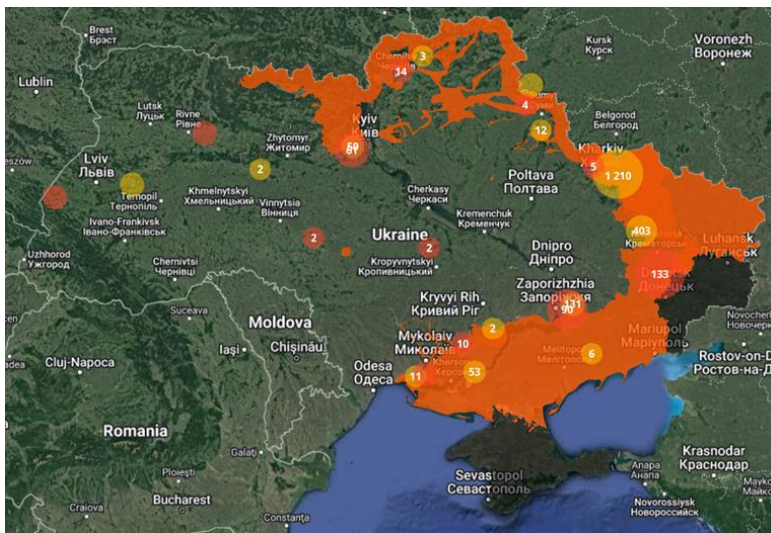


Fig. 2. Interactive map of territories that could potentially be contaminated by unexploded ordnance (according to the State Emergency Service of Ukraine, <https://mine.dsns.gov.ua>)



Fig. 3. A mine discovered during land surveying in the liberated territories in the Kharkiv region, February 2023.

In recent decades, surveying work relies on GNSS for precise measurements and positioning data. But since the beginning of the war radio-electronic warfare (REW) significantly impacts the civilian use of GNSS equipment and the performance of surveying work in front-line territories and during air attacks. REW systems can interfere with GNSS signals through jamming, which involves broadcasting radio frequency noise at the same frequency as the GNSS signals, effectively drowning out the satellite signals and rendering GNSS receivers unusable. This disruption can lead to inaccuracies, delays, or even complete loss of positioning information. In addition to jamming, REW systems can also employ spoofing techniques (especially during Russian strike drones' attacks), which involve transmitting counterfeit GNSS signals to deceive drone GNSS receiver into calculating false positions. This can cause severe issues for surveying work, as it may lead to incorrect data collection and inaccurate mapping of boundaries.

In the pre-war period, surveyors of Ukraine, thanks to the rather liberal legislation regarding the use of UAVs, quite intensively used drones for operational topographic mapping and creation of orthophoto plans. Since the beginning of the war, the airspace is closed to civilian aircrafts (including unmanned ones), and only a very small part of local cartographic projects (mainly in the western regions) that receive permits from the General Staff of the Armed Forces and Air Defense are being successfully implemented. The received remote sensing data also require additional counterintelligence verification to extract information about the location of defense facilities and other sensitive data.

Considering the aforementioned changes in land surveying in Ukraine under wartime conditions, it is important to evaluate the impact of the conflict on the industry, both in terms of economic and human dimensions.

Since the vast majority of land surveying work performed in Ukraine (about 80%), as in many European countries [2], is related to the definition of boundaries and cadastral registration of land plots, for an approximate assessment of the losses of the land surveying industry in Ukraine as a result of the war, we used such an indicator as the number of land plot registrations.

Comparing the number of applications for the registration of land plots in the State Land Cadaster for 2021 (2.012 million) and 2022 (653 thousand), it can be concluded that the land surveying industry lost approximately 67.5% of its pre-war revenue as a result of the war. Fig. 4, which shows the number of monthly land registration applications for the period from January 2019 to March 2023, clearly illustrates the dynamics of the industry during the wartime period (highlighted in color).

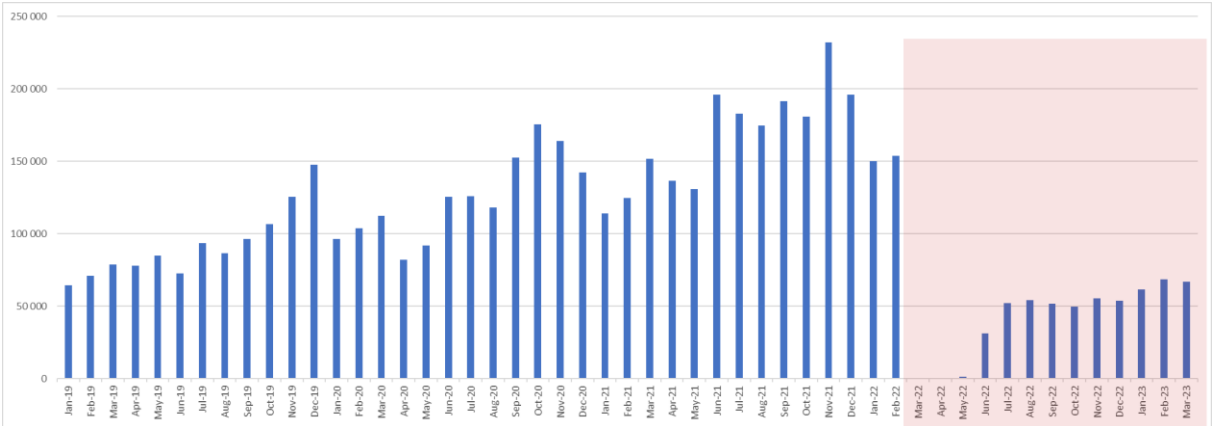


Fig. 4. Number of monthly applications for registration of land plots in the State Land Cadaster of Ukraine for the period from January 2019 to March 2023 (data from the State Service of Ukraine for Geodesy, Cartography and Cadaster).

According to estimates of professional associations of land surveyors in Ukraine, the pre-war volume of the land surveying market amounted to UAH 4.3-4.6 billion per year (€130-138 million). Thus, as a result of the war in 2022, the land management industry of Ukraine lost about UAH 3 billion in revenue (about €90 million).

15-20% of the market revenues decline can be explained due to temporarily occupied / vacated territories, where land management and land assessment works are not performed, or are performed with significant difficulties. For example, the Kharkiv region was one of the pre-war leaders in terms of land surveying and spatial planning works. In 2021, this region was chosen for the pilot development of new



promising types of land surveying documentation – comprehensive spatial development plans for two territorial communities. Their approval was planned for March 2022, but it did not happen due to Russian aggression.

Another 10-15% decrease in the industry's income in 2022 is due to the suspension of funding of land surveying and land assessment works by the state and local communities (state budget cuts for land reform implementation – UAH 139 million; state-wide topographic-geodetic and cartographic works – UAH 32 million, etc.). The corresponding funds were redirected to defense and crisis response. Only in March 2023, the Government of Ukraine restored the possibility of public procurement of land surveying and land appraisal works.

Thus, after the complete stoppage of land surveying production in March-May 2022 due to the suspension of the State Land Cadaster, the gradual recovery of the industry continues. Currently, at the beginning of 2023, the level of only 60-65% of the average monthly indicators of the pre-war level has been reached.

It is also important to examine how the war affected surveyors on a human scale. In this article, based on previous research [1], we have attempted to estimate the number of professional land surveyors, surveyors and land valuers working in the regions most affected by the war (Table 1). These surveyors were forced to become internal and external refugees, they or their relatives may remain in the occupied territories, deprived of the opportunity to work normally in their profession due to existing threats to life, loss of clients and regulatory restrictions. The regions most affected by the war are Luhansk, Donetsk, Kherson and Zaporizhzhia regions. Significant territories of the Kyiv, Kharkiv, Sumy, and Chernihiv regions were liberated from the aggressor, but they suffered the devastating effects of the war.

Table 1

Estimation of the number and share of land surveyors, geodesists and land appraisers who worked in the regions most affected by Russian aggression<sup>4</sup>

Type of region		Land surveyors			Geodesists			Land Appraisers		
		Men	Women	Total	Men	Women	Total	Men	Women	Total
Regions that are partially under occupation	number	146	133	279	56	18	74	56	60	116
	%	8,3	11,5	9,6	8,2	9,0	8,4	9,5	10,9	8,4
Liberated regions that have undergone hostilities	number	508	367	875	194	58	252	240	228	468
	%	28,8	31,9	30,0	28,5	29,0	28,6	40,6	41,5	28,6
Other regions	number	1108	652	1760	430	124	554	295	262	557
	%	62,9	56,6	60,4	63,2	62,0	63,0	49,9	47,6	63,0
In total	number	1762	1152	2914	680	200	880	591	550	1141

As we can see, up to 10% of surveyors of Ukraine were in the regions that are currently most affected by the war, and up to 30% come from regions where hostilities and mass destruction took place. However, it is also worth noting that almost 40% of land surveyors, 23% of geodesists and 48% of land appraisers are women, who in times of war are often forced to take responsibility for the safety of children and elderly family members, seeking shelter in safer regions or abroad, thus losing the opportunity to work by profession.

When examining the primary aspects of the strategy for the recovery of the surveying industry, it is important to emphasize that the principal expectations lie in the post-war restoration efforts. The following important initiatives for the industry can be identified:

<sup>4</sup> We also have to warn that the estimates given by us may be incomplete, since the presented statistics cover only certified specialists registered in the relevant state registers. It is clear that there are a significant number of professional surveyors who work in support positions or in businesses where certification is not required (such as construction companies, agribusiness or universities, etc.)

- Land surveyors are instrumental in evaluating and documenting the extent of damage inflicted on buildings, infrastructure, and natural resources during a war. By utilizing their expertise in geospatial data collection and analysis, land surveyors can create comprehensive maps and reports detailing the destruction caused by the conflict. This invaluable information aids in identifying the most affected areas and prioritizing reconstruction efforts, ensuring the efficient allocation of resources for rebuilding and restoration. Furthermore, accurate damage assessments can support claims, government compensation programs, and international aid initiatives, helping affected communities recover more swiftly from the impacts of the war.
- The project of the National Plan for Recovery from the Consequences of War<sup>5</sup>, which was presented in August 2022, provides for new mapping of the territory of Ukraine and the development of the National Geospatial Data Infrastructure (NSDI). It is obvious that without providing up-to-date cartographic data, the post-war recovery and development of territories is impossible. Implementation of NSDI, including land monitoring, will ensure effective adoption of management decisions by state authorities and local self-government bodies, meeting the needs of society in all types of geographic information, integration into the global and European infrastructure of geospatial data. The expected effective use of geospatial data will lead to GDP growth of up to 1% per year. Estimated budget of UAH 3.3 billion. (\$110 million).
- The development of comprehensive plans for the spatial development of the territories of territorial communities is considered an important tool for post-war reconstruction. More than 150 communities have already decided to develop such plans, which contain a heavy land surveying part. In 2023, it is planned to develop (update) several pilot comprehensive plans for communities affected by hostilities.
- The identification of areas affected by hostilities and land reclamation efforts are becoming increasingly significant. It is crucial to include information about territories contaminated by explosive objects (accounting for more than 21% of Ukraine's territory) in the State Land Cadaster, ensuring effective information interaction with IMSMA<sup>6</sup>. This step is necessary for implementing fiscal policies and exempting hazardous real estate from taxation. A vital component of restoration efforts includes post-demining land reclamation, soil cover restoration, and exploring alternative uses for lands with long-term contamination.
- The war caused damage to Ukraine, which is measured in hundreds of billions of euros, but currently the estimated annual amount of financing for reconstruction in the post-war years is 15-20 billion euros. Topographical and geodetic support for construction, depending on the types of reconstruction, will be from 0.3 to 1.2% of the estimated cost. Planned expenditures for reconstruction in 2023 in the State Budget of Ukraine - 23 billion UAH (that is, UAH 120-200 million will go to topographic and geodetic support).

### **Conclusions and proposals**

The key provisions of the strategy for the recovery of land surveying in Ukraine from the consequences of the war focus on rebuilding the industry's infrastructure and human resources while adapting to the new realities of a post-war environment. This includes conducting thorough damage assessments to document the impact of the war on buildings, infrastructure, and natural resources, and prioritizing reconstruction efforts. Investment in modern technologies and equipment is also vital to enhance the accuracy and efficiency of land surveying practices, while efforts to re-establish disrupted services, such as the State Land cadaster and other registration systems, will ensure the continuity of land management and spatial planning processes. Another crucial aspect of the recovery strategy is the retention and development of the land surveying workforce. Implementing policies and programs to retain existing professionals, attract new talent, and provide retraining and educational opportunities will help rebuild the industry's human resources. Collaborating with international organizations and experts to exchange knowledge, best practices, and resources will further support the recovery and development of the land surveying industry in Ukraine. Raising public awareness and engaging stakeholders are essential in

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<sup>5</sup> URL: <https://www.kmu.gov.ua/en/national-council-recovery-ukraine-war/working-groups>

<sup>6</sup> The Information Management System for Mine Action is a software designed to support the needs of the mine action community for decision support, monitoring and reporting. Core elements of IMSMA include a PostgreSQL database engine and a GIS for displaying information on maps.

garnering support for the land surveying industry and emphasizing its role in post-war reconstruction efforts. By fostering a broader understanding of the industry's importance and its contribution to rebuilding, the long-term resilience and growth of the land surveying sector can be ensured.

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