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## DEVELOPMENT DRIVERS AND APPLICATION PRACTICE OF HIGH-PRECISION GUIDED MUNITIONS

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High-precision guided munitions (HPGMs) are means of destructive equipped with a control system, high-tech guidance and global positioning systems and/or an integrated inertial navigation system to identify military targets. High-precision guided munitions include tactical missiles, guided missiles, guided munitions (including aircraft bombs), and loitering munitions.

It is worth emphasising that one of the main factors that caused the creation and became a development driver of the HPGMs are the accelerated trends defence budgets. Thus, the US defence budget has been growing steadily since 2014 and in 2021 its amount was USD 806.23 billion against USD 647.79 billion in 2014, changing with an average annual growth rate of 24.46% [1]. In 2023 the US



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defence budget has increased by 6.4% and amounted to USD 916.01 billion against USD 860.69 billion in 2022 (tab. 1).

Table 1

**Cross-country trends of the defence budgets growth**

Countries	Defence budget, billion USD						
	2014	2021	Growth rate 2021/2014, %	2022	2023	Absolute growth	Growth rate 2023/2022, %
USA	647.79	806.23	24.46	860.69	916.01	55.32	106.43
China	182.11	285.93	52.82	291.96	296.44	4.48	101.53
Israel	17.74	24.34	37.23	23.41	27.5	4.09	117.47
Western European countries	265.44	303.99	14.52	299.59	344.7	45.11	115.06
Baltic countries	1.235	2.878	133.12	3.409	4.396	0.987	128.95
Poland	10.35	15.29	47.85	15.34	31.65	16.31	206.32
Ukraine	3.96	6.89	74.13	41.18	64.75	23.57	157.24

Source: calculated based on data from [1]

It should be emphasised that the aforementioned trend of defence budgets changes is also typical for the former USSR. Thus, the average growth rate during 2014-2021 amounted to 81.82%. As for 2023 compared to 2022, the average growth rate of defence budgets in these countries amounted to 41.59%. Simultaneously, the defence budgets changes analysis also indirectly indicates the existence of other HPGMs development drivers, namely increasing wars and local military conflicts number, and the countries' growing demand for such ammunition to defend their borders in 2022-2023 in response to the war in Ukraine. This also closely correlates with the national armed forces modernisation programmes. Given that HPGMs are high-tech weapons, it is quite reasonable that innovative technologies are also their development driver.

Analysing the global HPGMs market, the fact of its segmentation has been revealed, first of all, by the type of munitions, which should be divided into: guided aerial bombs, cruise missiles, short- and medium-range ballistic missiles, anti-tank missiles, guided artillery shells, unmanned aerial vehicles (kamikaze drones).

In 2022, the market capitalisation was evaluated as USD 36.8 billion, and in 2024 it reached USD 41.22 billion. It is expected to reach USD 63.9 billion in the short term, with an average annual growth rate of 7.04%. [2]. In addition, the capitalisation of the aircraft bombs market (guided and unguided) was estimated at USD 20 billion in 2023 and according to forecasts, it will reach USD 24.7 billion in 2032, with an average annual growth rate of 2.38% [3].

During the Russian-Ukrainian war full-scale phase, Ukraine was attacked by the aggressor's guided bombs (GBU). It should be noted that GBU is an aircraft weapon equipped with a guidance system that allows to adjust its flight path to precision target defeat without entering the air defence area. Active GBU usage took place in the second half of the twentieth century (Korean, Vietnam and Arab-Israeli wars, the Gulf War, military operations in Yugoslavia). Their modern history is associated with military operations in Afghanistan and Iraq, the military conflict in Syria, and the war in Ukraine.

The GBU was developed with the following objectives: 1) high accuracy of target destruction, i.e. ensuring the permissible deviation from the intended destruction point no more than ten metres; 2) minimising damage around the destruction target when the munition is used in urban operations, which is intended to reduce the casualties risk among the civilians and infrastructure. GBUs also have the following characteristics: defeat range, versatility, modularity, effectiveness in all weather conditions, high single-strike efficiency, and ability to be used from different platforms (fighters, strategic bombers, unmanned aerial vehicles). However, Russia uses against Ukraine the following GBU nomenclature: GAB (Guided Aerial Bomb) - 1500V, 'Grom-E2', 'Grom-E1' hybrid bomb, 'Drill' cluster bomb, as well as universal planning and correction modules, which include high-explosive aircraft bombs of 250 to 3000 kg calibre.

During the war, more than 51,000 GBUs have been launched in violation of the Geneva Convention relative to the Protection of Civilian Persons in Time of War [4], striking civilian objects and infrastructure in Ukraine, causing destruction and numerous casualties among the civilians (Fig. 1).

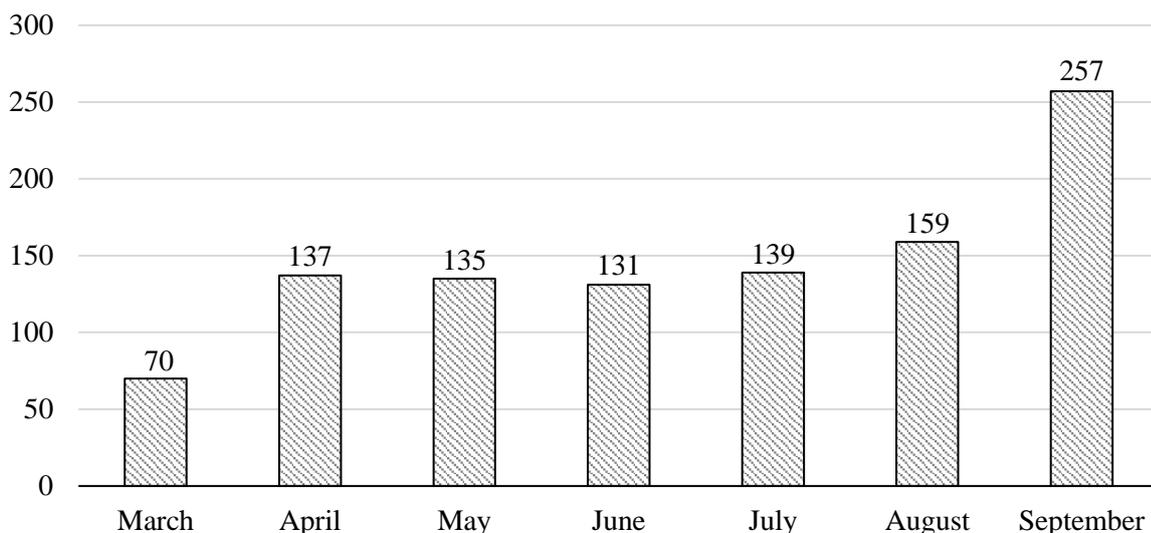


Fig. 1. **Amount of GBUs used against Ukraine in 2024**

Source: compiled based on data [4]

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Thus, in March 2024, Russia guided UCSPM (Universal cross-species planning munition) D-30SN (250 kg) into a playground near a residential building and a metro station in Kharkiv, causing 20 casualties (1 person was killed) and damaging 18 residential buildings. In May 2024, UCSPM D-30SN (3 x 250 kg) hit the Epicentre shopping centre, killing 73 people (19 killed, 54 injured) and causing environmental damage of UAH 860 million [5]. During the last week of November 2024, Russia launched more than 800 GBUs.

Ukraine has received and is using GBU JDAM-ER (USA, Australia), GBU-12 Paveway II, GBU-24 Paveway III, GBU-39 (USA), Paveway IV (UK), AASM HAMMER (France) as part of international technical support. Since 2023, Ukraine has been using the 500-pound (227 kg) JDAM-ER bomb, and in 2024, it became the first in the world to use the 1,000-pound (454 kg) Mark 83 bomb, which is specially adapted for the use of the JDAM-ER planning and correction kit for the Air Force of Ukraine. The Armed Forces of Ukraine have chosen upgraded MiG-29 and Su-25 aircraft as GBU launch carriers/platforms. For instance, GBU-39s were used in the Kharkiv region to hit a Russian depot and command post. In September 2024, the US government signed a multi-year contract until 2035 worth \$6.9 billion with Boeing to produce a new batch of GBU-39/Bs for its Air Force and foreign customers, which included Ukraine with Japan and Bulgaria along with foreign military sales (FMS) [6].

Thus, given the ever-increasing smart bombs demand, the logistics and adaptation complexity of foreign-made GBUs, Ukraine's urgent need is to establish its own GBU production with perspective tactical and technical characteristics by mastering new high-tech development approaches to national defence strengthen.

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