Review of Artillery Smart Ammunition

Mohamed Abdelnasser Asar, and Fares Kamal Ail
Military Technical College, Egypt

Supervisor: Brig. Gen. Dr. Ossama Ramy, Chief of the department of Weapons & Ammunition,
Military Technical College, Cairo, Egypt

Abstract– Precision has always been recognised as an important attribute of weapon systems development. Accuracy of aim is one of the five recognizable attributes of weaponry, together with range of action, striking power, volume of fire, and portability. Considering that, smart ammunition is save money and effort, whereby one of these types can be done with the effect of a huge number of unguided ammunition that is for there have high accuracy and precision.

This paper presents a review of different kinds of smart Ammunition. Precision-guided munitions (missiles, Ammunition air bombs), are exposed, showing their importance in up-to-date combats.

Wire, Inertial Navigation guidance system combined or not with GPS (INS/GPS), The Joint Direct Attack Munitions (JDAM) Laser guided systems (LGS) and Radar (Active –Semi-active) guided munitions are represented showing the principal of work of each kind as well as their advantages and accuracy. Some examples of different kinds are provided.

Studying This paper helps to select suitable Ammunition for different purposes in action during combat, taking into consideration the expense, accuracy, and complication during use.

I. Introduction

The smart ammunition is save money and effort, where by one of there type can done the effect of a huge number of unguided ammunition, that's for there have high accuracy and precision.

A precision-guided munition (PGM, smart weapon, smart munition, and smart bomb) is a guided munition intended to precisely hit a specific target, to minimize collateral damage and increase lethality against intended targets. [1] During the First Gulf War guided munitions accounted for only 9% of weapons fired, but accounted for 75% of all successful hits. Despite guided weapons generally being used on more difficult targets, they were still 35 times more likely to destroy their targets per weapon dropped. [2]

We scope some type of guidance system are Wire-guided missile, Inertial guidance system, The Joint Direct Attack Munition(JDAM), laser guidance system (LGS), and Radar guidance.

II. Wire-guided missile

In this kind of missile that is guided by signals sent to it via thin wires connected between the missile and its guidance mechanism.

The longest-range wire- guided missiles in current use are limited to about 4 Km (2.5 mi).

Electrical wire guidance is used at 20th century such as the Lay Torpedo. A ground Germans created based electrical wire-guided Torpedo during World War II.

Lage numbers of Israeli tanks were destroyed by using wire Wire-guided missile (AT-3 Sagger) during the Yom Kippur War of 1973.

Wire guidance has remained the main system for smallest Weapon, however new system as Laser-guided has been used in anti-aircraft and some of anti-tank weapons.

Some torpedoes is Wire-guided, which is guided by insulated wire, such as (the U.S. MK 48 Advanced Capability (ADCAP) torpedo, Russian (UGST) torpedo)

-Principal of work:

It is a missile that is guided by signals sent to it via thin wires connected between the missile and its guidance mechanism, which is located somewhere near the launch site. As the missile flies, the wire are reeled out behind it (command guidance). this guidance system is most commonly used in anti-tank missiles, for its ability to be used in areas of limited line-of sight make it useful, while the rang limit imposed by the length of the wire is not a serious concern. It is important to mention that this kind's accuracy depend on the combatant level completely.

III. Inertial guidance system

Inertial Navigation The most common type of NG is Inertial Navigation (IN), usually found in missiles following a near ballistic or a cruise trajectory. Atypical IN trajectory, this represents a missile moving in the plane of the page, as shown in Figure Eight. Before launch, the positions of the launch point L and target T (or desired point of impact) are known. These locations are fed into a guidance computer on board the missile, probably in the form of co-ordinates (XL, YL) and (XT, YT). After the missile is launched, it is the task of the inertial navigator to measure the distance moved by the missile parallel to the reference axes OX and OY. If these measurements are made and fed to the guidance computer, it will then have all the information needed to correct any error in the missile position by passing steering instructions to the control system. The measurement of missile displacement in space is carried out by measuring the acceleration in three mutually perpendicular directions. In Figure Eight, only two dimensions are concerned but, in general, there will be three; in the diagram, this would be OZ, directly out of the page.

With the acceleration in the X, Y and Z directions known at every instant in time, the computer can first calculate the missile speed in the three directions at every instant and then the distance moved in the three directions. In mathematical terms, this is called double integration with respect to time.

Sometime the inertial guidance system is working with another to be working better be improve the accurate and precision, for example using inertial guidance with GPS guidance (M982 Excalibur).

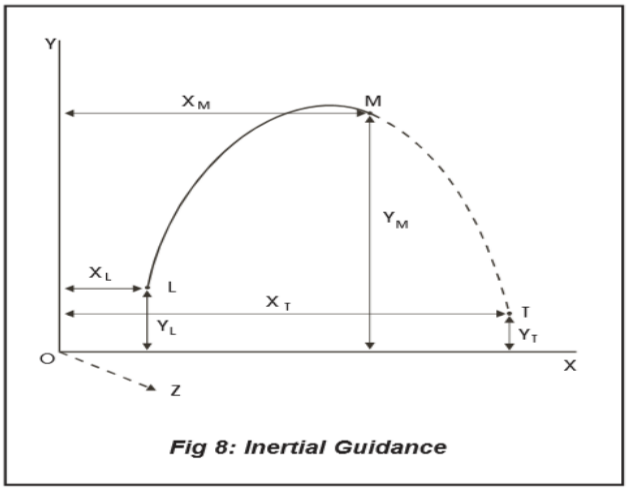


Fig 8: Inertial Guidance

IV. The Joint Direct Attack Munition (JDAM)

Is a guidance tail kit that converts existing unguided free-fall bombs into accurate, adverse weather "smart" munitions? With the addition of a new tail section, that contains an inertial navigational system and a global positioning system guidance control unit, JDAM improves the accuracy of unguided, general-purpose bombs in any weather condition.

Once released from the aircraft, the JDAM autonomously navigates to the designated target coordinates. Target coordinates can be loaded into the aircraft before takeoff, manually altered by the aircrew before weapon release, or automatically entered through target designation with onboard aircraft sensors. In its most accurate mode, the JDAM system will provide a weapon circular error probable of 5 meters or less during free flight when GPS data is available. If GPS data is denied, the JDAM will achieve a 30-meter CEP or less for free flight times up to 100 seconds with a GPS quality handoff from the aircraft.

JDAM can be launched from very low to very high altitudes in a dive, toss or loft and in straight and level flight with an on-axis or off-axis delivery. JDAM enables multiple weapons to be directed against single or multiple targets on a single pass.

Desert Storm highlighted to JDAMs, where More than 450 JDAMs were dropped during this testing, recording an unprecedented 95 percent system reliability while achieving a 9.6-meter accuracy, however adverse weather conditions. JDAM performance has been demonstrated in operationally representative tests including drops through clouds, rain and snow. These tests included a B-2 releasing 80 JDAMs on a single pass against multiple targets.

JDAM is currently compatible with B-1B, B-2A, B-52H, AV-8B, F-15E, F/A18C/D/E/F, F-16C/D and F-22 aircraft. Follow-on integration efforts are currently underway or planned to evaluate compatibility with the A-10, F-35 Joint Strike Fighter and MQ-9 Reaper unmanned aerial vehicle.

V. Laser Guidance System (LGS)

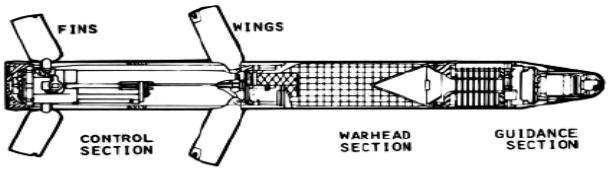
It is type of guiding systems, which depends mainly on the technology of laser guidance. LGS is used to guide artillery rounds and aircraft bombs.

A- LGS is generally consists of:

1) Laser target designator.
2) Laser seeker.

B- LGS, which used in guided missiles:

1) War head section.
2) Navigation(control) section (which control wings and fins).
3) Guidance section (which contains laser seeker)

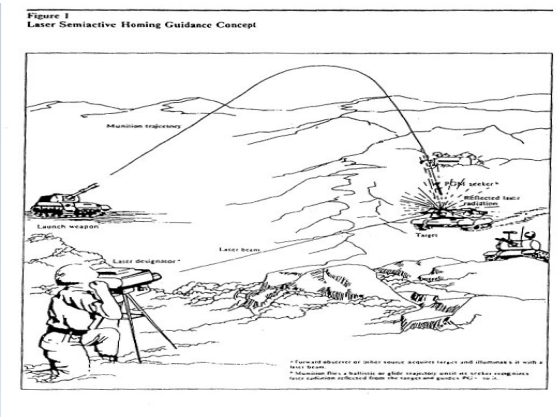


-The (LGW) laser guiding weapons have guidance module contains an inertial reference system, a power source, various electric motors and controls and four folding canards used to execute command guidance signals.

C-How the LGW work:

1) The projectile is tracking a light signature, not the object itself, the target must be illuminated be a separate source, either by ground forces, by a pod on the attacking aircraft, or by a separate supporter aircraft.

2) The laser target designator is then used to illuminate the target and the in-flight projectile detect the radiant laser energy reflected by the target and the navigation system steers the shell towards the point of greatest incident energy—the designated target with top attack pattern.



-Advantage of LGW:
-It is capable of hitting targets moving at speeds up to 36 km/h (22 mph).
-Circular error probable (CEP) is about 2.6 to 5.9 ft (0.8 to 1.8 m)
-Disadvantage of LGW:
-Un useful for targets that not reflect laser light, or painted with (SALH).
-Gives boor results in dusty weather.
-Have a big error when working in fog or smoke.
-Information about LGW:
-LGW were first developed in the united states in the early 1960s
-Were first used in Vietnam ware in 1968
-Its type-high explosive fragmentation warhead.
-Examples:
M 114, M 109, M 198, M 777, CAESAR and M712 Copperhead
- M712 Copperhead:
-It is a laser guided pomp.
-caliber: 155 mm
-weight: 137.6 kg
-Range:
Minimum range: 3 km
Maximum range: 16 km
-Projectile weight: 14.75 kg
-Length: 140 cm
-Used by: Egypt, USA, Jordan, Taiwan and Lebanon.

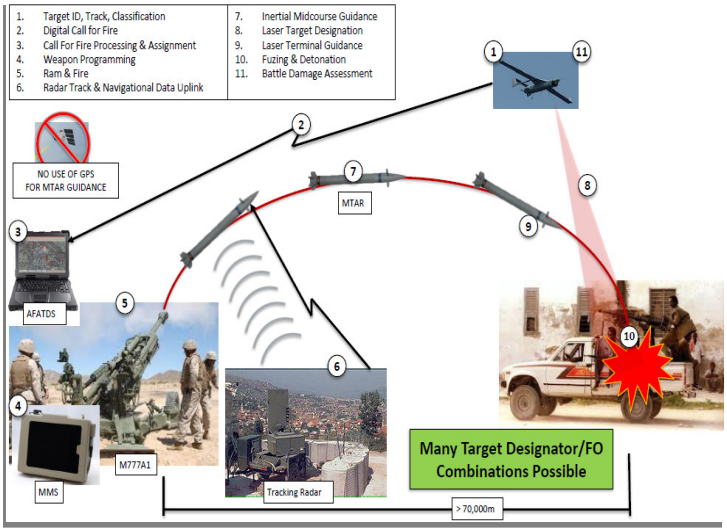
VI. RADAR GUIDANCE

radar guidance like infrared (IR) homing guidance is predominantly used in surface-to- surface and air-to-air guided weapons. While IR guidance is used in short and medium ranges, And radar guidance long range. Where operational ranges in excess of 150 km.

in which a radar is used to designate the intended target with electromagnetic energy, and the missiles make use of radar energy reflected from the target to steer itself to intercept and destroy the target.

Another difference is in their operational ranges, which are much larger in the case of radar-guided missiles, approaching 150 km to 200 km in the case of state-of-the-art air to-air missiles than in the case of laser-guided munitions that seldom exceed 20 km.

The basic concept is the same as the one used in the case of laser-guided munitions, except for the fact that laser-guided munitions are largely surface-to-surface and air-to-surface weapons and radar-guided weapons are mainly air-to-air and to a limited extent surface-to-air missiles.

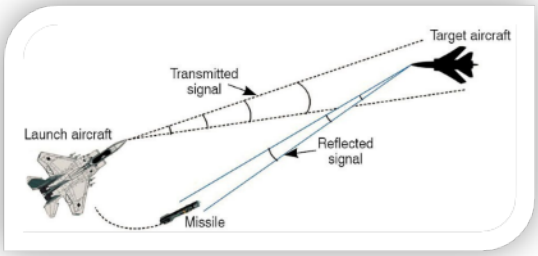


A.1). Active radar homing (ARH)

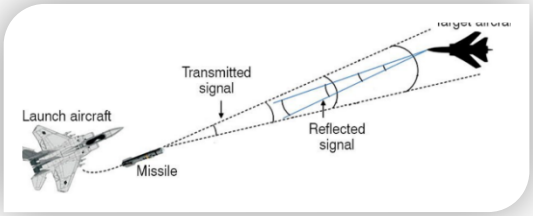
A missile contains a radar transceiver (in contrast to semiactive radar homing, which uses only a receiver) and the electronics necessary for it to find and track its target autonomously in a missile guidance method. The NATO brevity code for air-to-air active radar homing missile launch is fox three. [3]

A.2). Semi-active radar guidance

It is system, the target aircraft is illuminated by electromagnetic energy emitted by the re control radar located either on the launch aircraft or at an appropriate ground location. The re control radar acquires the target and tracks it. A small radar transmitter generating a very narrow beam then selectively illuminates the target using tracking information generated by the re control radar. A radar receiver onboard the missile receives the radar energy reflected from the target and locks on to the target.



Active radar homing guidance basic concept



Semi-active radar homing guidance basic concept

B.1). Advantages

As the missile is tracking the target it is going to be much closer to the target than the launching platform during the terminal phase, thus the missile's tracking can be much more accurate and better resistant to electronic countermeasure Active radar homing missiles have some of the best kill probabilities along with missiles employing track-via-missile guidance.

- Because the missile is totally autonomous during the terminal phase, the launch platform does not need to have its radar enabled at all during this phase, and in the case of a mobile launching platform like an aircraft, can actually exit the scene or undertake other actions while the missile homes in on its target. This is often referred to as fire-and-forget capability and is a significant advantage that modern air-to-air missiles have over their predecessors.

B.2. Disadvantages

Because most missiles are powered by rocket motors, they have no on-board electricity generation capability. This means that active radar-guided missiles usually rely on battery power for the radar transmitter, significantly limiting its power - although this can be mitigated by employing the designs described below.

- Because a complete radar system is implemented, an active system will be more expensive than a semi-active system if all other factors are equal.

.

VII. Examples

A. BGM-71 TOM (Wire-guided missile)

An M41 tripod-mounted TOW ITAS-FTL with PADS of the U.S. Army in Kunar Province, Afghanistan, in May 2009, Type Anti-tank missile, Place of origin United States. Designer by Hughes Aircraft Company, Designed in 1963–1968, Diameter 152 mm, Warhead weight 3.9–6.14 kg (penetration 430–900 mm RHA)[6], Wingspan 0.46 m Operational range Basic TOW 3,000 m, most variants 3,750 m, Maximum speed is 278–320 m/s Guidance system Optically tracked, wire-guided (wireless radio-guided in RF variants)

B. M982 Excalibur (Inertial guidance system with GPS)

Type is Guided artillery shell, Place of origin is Sweden, United States, Used by Canada, Germany, India ,Italy, Ukraine, Netherlands, United States, Sweden. Manufacturer BAE Systems AB: Bofors Raytheon Missiles & Defense. Mass is 48 kg (106 lb)[5], Length is 100 cm (39.2 in) , Caliber is 155 mm , Effective firing range is Increment Ia-1: 23 km (14 mi) Increment Ia-2/Ib: 40 km (25 mi)[6] newest test: 70 km[7], Warhead is Warhead, Warhead weight is 22 kg[8] ,

Guidance is GPS, inertial navigation system , Accuracy is 4 m CEP.

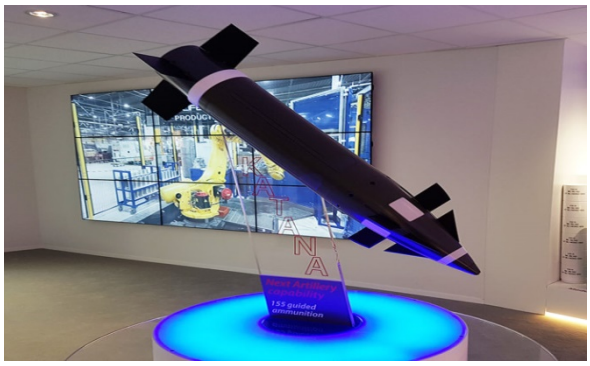
C. GBU-31 (JDAM)

GBU-31: A Mk84 bomb fitted with JDAM kit. Type Bomb guidance kit, Place of origin is United States. In service from 1997 until now. Unit cost About US$25,000. Length is 9.9–12.75 feet (3.02–3.89 m), Maximum firing range Up to 15 nautical miles (28 km), Wingspan is 500 to 640 mm, guidance inertial system system with GPS. Accuracy is 13 to 7 m.

D. The kvinyk (152 and 155 mm) (LASER guidance)

Destroys from the first shot, meets NATO standards, laser semi-active homing head calibre 152/155mm, digital control system, projectile weight up to 50kg, shooting range up to 20km, type of warhead high-explosive fragmentation, hits targets moving at speeds up to 36km/h, hits target the size of a sheet of A4 paper from a distance of 20km, made without Russian components, a limited number of counters have technology for high-precision projectiles.

E. The KATANA (155 mm) shell (Radar guidance)



The KATANA is a 155mm shell that can be fired from all 52-caliber artillery systems, the permanence of fire, producing cost-effective firepower in all-weather and complex environments, Katana achieves long-range, decametric accuracy around 10m, KATANA can engage stationary priority targets based on their coordinates. The French round is the only European and sovereign full-calibre guided ammunition.

VII. Conclusion

Finally, the guidance system can be arranged according to their accuracy as following, in the fist the LASER guidance, which it's accuracy reach (0.8 to 1.8 m) put it is very expensive and it is needed to crew to fire it, and LASER source, thin Inertial guidance system with GPS it's accuracy reach 4 m CEP, and it less expensive than LASER guidance system, it easier than guidance system in using, next then radar guided it is use almost as a rocket guidance system, next then JDAM ,which it's accuracy reach (13 to 7 m),put it cheaper than the LASER guidance and the Inertial guidance system, it almost use with aircraft, at least the wire guidance. At the end radar guided systems gave the accuracy around 10 meter .

References

[1] Hallion, Richard (1995). "Precision guided munitions and the new era of warfare" (http://www.fas.org/man/d

[2] "Bursts of Brilliance - The Washington Post" (https://www.washingtonpost.com/archive/lifestyle/magazine/2002/12/15/bursts-of-brilliance/0c06b132-2d70-41e6-882e-5c4ece8f5fcf/). The Washington Post.

[3] globalsecurity.org (http://www.globalsecurity.org/military/library/policy/army/fm/3-54-10/fm3-5 4-10.pdf): Brevity: Multi-Service Brevity Codes (retrieved 19 June 2013).

[4] ^ ARG. "TOW Anti-Tank Guided Missile – Military-Today.com". military-today.com. Archived from the original on 22 September 2017

[5] "Development of the XM982 Excalibur Fuzing System" (http://proceedings.ndia.org/5560/We dnesday/Session_III-A/Gudjohnsen.pdf) (PDF). 7 April 2005. Archived (https://web.archive.o rg/web/20160224054943/http://proceedings.ndia.org/5560/Wednesday/S ession_III-A/Gudjo hnsen.pdf) (PDF) from the original on 24 February 2016. Retrieved 18 September 2013.

[6] "Excalibur XM982 Precision Engagement Projectiles" (https://web.archive.org/web/2016012 6220400/http://www.dote.osd.mil/pub/reports/FY2007/pdf/army/2007ex calibur.pdf) (PDF). Office of the Director, Operational Test & Evaluation. 2007. Archived from the original (http:// www.dote.osd.mil/pub/reports/FY2007/pdf/army/2007excalibur.pdf) (PDF) on 26 January 2016. Retrieved 29 August 2012.

[7] "【本周軍事新聞】2020/12/20 － 12/26" (https://vocus.cc/article/5fe3e4ddfd897800018eb92 b) [【Military News of the Week】2020/12/20－12/26]. vocus.cc. 26 December 2020.

[8] ARG. "M982 Excalibur Extended-Range GPS-Guided Projectile" (http://www.military-today.c om/artillery/m982_excalibur.htm). Military-Today.com. Retrieved 10 March 2022.