

OME Assignment_Atkins 1809912

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Principles of OME – ACDA 5010

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1.1 Introduction

The aim of this report is to discuss the processes that should be undertaken to achieve a successful design of a particular high explosive device as an example of general procedures applicable to reliable procurement.

A Military requirement has been raised for a guided targets blast bomb to be delivered by a RAF Eurofighter Typhoon for the attack of a fortified underground building.

Existing methods which are designed to achieve the requirement;

The ancestor of the “bunker buster” was used during World War II to collapse walls. Governments began to protect facilities by placing them underground in fortified bunkers. These bombs were designed to penetrate into the earth in order to target the deeply buried facilities. While there have been many conventional bunker busters introduced in recent years, the B6 family of weapons includes nuclear weapons with a capability to reach underground targets. For example, the nuclear B61-11 bomb was developed to destroy targets below the Soviet Union’s frozen hard earth. This is not seen as an ideal solution due to the hazards presented by the resulting nuclear fallout [1].

An example of a conventional model of bunker buster is the Guided Bomb Unit (GBU-28). Its body is constructed from an artillery barrel with approx. 295 kg of Tritonal as its main charge. Tritonal is a mixture of TNT/Aluminium (80/20). The GBU-28 is 5.8 meters long, 36.8 cm in diameter and weighs nearly 2 tonnes [2]. This bomb unit is dropped from high altitude in order to gain the sufficient kinetic energy required to penetrate the ground.

The MOP (Massive Ordnance Penetrator) is a new bunker buster that is heavier, safer, and more effective than the Guided Bomb Unit (GBU-28), or the nuclear model. The MOP is guided by GPS and is a 200 feet long bomb that weighs 30,000 pounds, and contains nearly 6,000 pounds of high explosives. It is expected to penetrate as deep as 200 feet through reinforced concrete that is able to withstand pressure of 5,000 pounds per square inch, which is deeper than any existing nuclear weapon [1] Although highly effective, the size and weight are major issues to contend with and very limited aircraft can fly with the MOP, let alone get it to the required altitude.

For a guided weapon to be successful it must contain the following;

- A propulsion unit to impart sufficient velocity enabling it to reach the target.
- A guidance package to receive command signals from the ground or to provide information about the missile’s flight path.
- A control unit to act on the commands from the guidance package and interpret them in order to control surface movement.
- A form of armament, consisting of warhead, fuzing system and safety and arming mechanism, to destroy the target.
- An airframe or structure; to house the components and to provide the missile with an ability to manoeuvre.

[3]

1.2 Method - Requirements

A Military requirement has been raised for:

A guided blast bomb to be delivered by the Eurofighter Typhoon, for the attack of underground bunkers. Based on historical and in-service munitions that aim to achieve this, the following user requirements are discussed:

1. The design must be compatible with a Eurofighter Typhoon. It must be possible for the GW (Guided Weapon) to attach to the aircraft.

The Eurofighter Typhoon has 13 hard points for weapon carriage, four under each wing and five under the fuselage [4]. In order to fulfil this requirement existing in-service attachment methods will be utilised. If the GW is not compatible then there is the potential for a malfunction or failure during the release of the GW. It could also mean the inability to attach the GW to aircraft.

2. The design must not be too heavy or large for the aircraft to carry.

This is a requirement that will be determined by the limits of the aircraft. The Eurofighter is capable of carrying approx. 10000kg of additional weight. In order for the GW to be successful it needs to be heavy and dense but not at the detriment of the aircraft not being able to carry it to the target. The GWs dimensions must also be practical as the aircraft must be able to taxi, take off and land with the GW attached.

3. Deep target penetration

This can be achieved by using a GW with materials of high density and mass. Also by narrowing the diameter of the bomb it will increase penetration. Increasing the velocity of the GW and therefore the kinetic energy as it hits the target will improve ground penetration. Failure to penetrate deep enough into the ground will result in a detonation nearer to the surface, which will reduce the effects desired.

4. The GW needs to hit the target with as much velocity as possible

This can be achieved by dropping the GW from a higher altitude or by attaching a method of propulsion. Failure to reach the required velocity will mean the GW does not penetrate deep enough into the ground and the detonation will be closer to the surface, reducing the underground effect.

5. The GW has to be sufficiently heavy/dense

This can be achieved by manufacturing the body and nose of the GW with tungsten (or other dense material that has material properties good for penetrating). The high explosives used in the main filling of the GW can be metallised (aluminium added) which increases the density. The GW will fail to penetrate to the desired depth if it is not heavy/dense enough.

6. The proposed design must be cost effective

The best way to fulfil this requirement is by using existing in service parts where possible (for example, the guidance section, rocket motor, fusing system and aircraft attachments). This saves money on designing and developing new parts. Failure to keep the project cost effective may result in the design being scrapped and not be further developed.

7. *The GW must be safe to handle/transport*

The use of insensitive munitions where possible. There will be a number of procedures required to arm the GW and it will be designed with the same safety features as current in service guided weapons. Failure to meet this requirement increases the risk of injury or death to personnel handling and transporting the bombs.

1.3 Proposed Designs

1.3.1 Design A

A GW which is air dropped, fin stabilised and laser guided by personnel on ground. The GW is made of two parts with separate warheads, a front shaped charge warhead and a rear section with an additional HE (high explosive) warhead. The shaped charge warhead is designed to create a large hole in the ground and the second warhead is designed to detonate within the cavity and create damage underground.

Functioning - The target is identified and painted using a current in service laser and the GW is dropped from the aircraft. The GW has a guidance section and can adjust fins to direct it to the target location. The GW hits the ground and a copper lined shaped charge warhead detonates at the optimum standoff (which is created with a nose cone). This will create a hole in the ground. The second warhead detonates below ground with the sudden deceleration of the base fuze.

The main issue with this design is relying on a shaped charge to penetrate deep enough for the weapon to be effective.

1.3.2 Design B

This design is made up of two separate GWs that are dropped almost simultaneously. The first GW to be dropped is very heavy and made up entirely of a dense material (i.e tungsten) with a guidance section and a rocket motor to increase its velocity towards the target. It does not contain an explosive charge and its only function is to penetrate the ground. The second GW is also propelled by a rocket motor and is guided by following the heat signature of the 1st GW. It is fitted with a fuze to initiate the main HE charge when it comes to a stop underground. It's aim is to get into the penetrated target and initiate to cause damage underground.

Functioning – Both GWs are dropped by the aircraft and the rocket motors begin. They both have the same flight characteristics and velocity. The guidance section of the 1st GW delivers it to the target. The 1st GW hits target and penetrates deep into ground/concrete. The 2nd GW (closely following) enters the hole created. The fuze is designed to detonate the warhead when it comes to rest underground. The 1st GW needs to be heavy/dense – Tungsten or Depleted Uranium. The 2nd GW warhead contains HE with a metalized explosive, one with a significant amount of powdered aluminium (density 2.7) added. Not necessarily thermobaric as such, but with much the same effect of producing a powerful and prolonged blast.

The most likely cause of failure for this design is poor accuracy of the 2nd GW and therefore possibly detonating on the surface rather than underground.. For the concept to be successful the two GWs must follow closely. Effective heat resistance is required to prevent heat damage to the guidance or

fuse section of the 2nd GW. This 2nd GW will also require a backup guidance section, so that in the event that the heat seeking guidance fails, the back-up guidance can still direct it to the target

1.3.3 Design C

A rocket propelled GW, which is guided to the target by various means (GPS, Painted target etc.). It has a long body and solid nose cone, manufactured from Depleted Uranium, to assist with ground penetration. The high explosive main charge is Tritonal (TNT/Aluminium). The fuze is designed not to initiate on impact but when the bomb reaches its destination below ground. This GW does not require dropping from high altitudes like current in service bunker busters, but can be dropped at more reasonable altitudes which allows it to be carried by multiple aircraft. This is due to the rocket motor which increases the velocity of the GW, so the kinetic energy at impact with the ground is as high as possible, which helps the GW to push its way through concrete/earth. Within the GW is a laser-guidance assembly and control section. The guidance and control systems steer the GW with fins that are part of the assembly. Attached to the end of the body are stationary fins that provide stability during flight.

The components of the system:

- Structure – an airframe to provide the necessary strength to carry the payload under various conditions. The skin creates a good aerodynamic shape and protects the internal components from mechanical or climatic damage.
- Propulsion System - necessary to propel the missile from to the target. A rocket motor.
- Guidance System - the navigator for the system and can recognize the position and velocities of the missile and the target
- Control System - pilots the missile on its flight path in response to signals received from the Guidance System.
- Auxiliary Power System - provides the power required by the missile in flight other than the propulsive power.
- Payload – The HE (TNT/AL) warhead
- Fuzing System - recognizes the optimum time to initiate the payload. For this GW it is when it comes to rest underground.

[5]

The desired properties of the materials;

The body and nose section will be constructed from Depleted Uranium alloyed with a small amount of titanium. Depleted uranium is 1.7 times heavier than lead, and 2.4 times heavier than steel and the addition of titanium increases its hardness. It also contains incendiary properties that increase the destructive power of the GW [2]. The warhead will be made up from a composition of 500kg of Tritonal.

In Design A, the shaped charge warhead would have to be extremely large to create the desired penetration. Design B uses the theory of using kinetic energy with a material good for penetrating, similar to current in service munitions, but by using two guided weapons falling together and being propelled with rocket motors. This achieves the penetration by using a heavy mass and increased velocity, but the two GWs would have to follow to within inches of accuracy hitting the target and therefore the chance of the second GW detonating closer to the surface is high. For these reasons, Design C is selected as the design to go forward into testing.

1.5 Test Programme for Design C

The trials that will be required to test the proposed design are as follows:

Phase 1 - Testing of the laser guided guidance section and ground penetration testing

A practice version of the GW, without the main charge and fuzing system, will be dropped by the aircraft at a designated altitude and the flight characteristics and accuracy of impact with the ground monitored. The penetration achieved against various types of targets will be measured. This phase of the trial is also used to see how the aircraft copes during flight with the GW and tests the bomb release mechanism.

Phase 2 - Testing of Energetic Effects

A replication of the main charge will be detonated at the average depth achieved in phase 1. The effects and results will be recorded. Holes will be drilled into different target surfaces to look at the effects, for example in sandy and rocky conditions, and concrete targets.

Phase 3 - Final testing

Prototypes of the proposed GW will be produced for final testing. It will be tested against targets that the military expect to encounter on operations.

Following a successful trial, the GW will be required to go through the safety testing regime for all munitions entering service (for example, drop tests, compatibility testing etc.).

1.6 Post Procurement Handling and Storage

The GW will contain a rocket motor and main charge warhead with means of initiation and will likely be stored as Hazard Division 1.1, Compatibility Group F.

The GW will be stored on a trolley system for ease of transport.

In service surveillance will be conducted to monitor the GW at regular intervals during its shelf life. This will include a visual inspection of the components.

During the handling of aircraft bombs and missiles, care is to be taken to ensure that the tails, vanes, identification plates, suspension, and/or lifting lugs are not damaged or distorted. Guided weapons must not be stored, transported or handled with the nose of one bomb pointing towards the base of another [6].

As the airframe of the GW is made from Depleted Uranium then the risks of radiation must be considered. There is unlikely to be any radiation hazard from depleted uranium munitions as contamination is unlikely to arise during normal storage and transport activities. The use of suitable shielding, packaging and handling techniques will ensure that external radiation exposure is kept as low as is reasonably practicable during normal storage and transport activities. Further risk assessments will have to be carried out in addition to that of conventional munitions [7]. Handling and transportation of DU ammunition is to be kept to a minimum and no work or movement is to be carried out without prior reference to a Radiological Protection Supervisor [8].

1.7 Discussion

The decision to include aluminium in the explosive charge improves the brisance of the TNT, i.e. the speed at which the explosive develops its maximum pressure. The addition of aluminium makes Tritonal about 18 percent more powerful than TNT alone.

The design proposed is similar to the GBU-28 bomb unit that is described in the introduction. It differs in that it has its own propulsion system which means that it can be dropped from lower altitudes, but it also hits the ground with a higher velocity. The charge size is also larger to increase the effects of the detonation underground. As there is more mass, a good penetrating structure, and higher impact velocity, the kinetic energy passing into the ground is much higher, so it should be very successful. The fuzing system, and the warhead, must be able to withstand the increased forces acting on the GW at impact with the ground

The final results of the testing will determine whether all of the user requirements will be met. The proposed design utilises technology from existing guided weapons, which ensures that the design is cost effective and reliable. The testing/trial plan is designed to test different functions of the GW. Another method of testing the concept, could be to conduct a trial using a scaled down version of the GW, which may be required if a suitable range location isn't available and also saves money. The data received from this may confirm the design works and gives confidence to the stakeholders involved.

1.8 References

- [1] NCNK Issue Brief The 'Massive Ordnance Penetrator' (MOP) Bunker Buster - Monica Kang and Karin Lee Last Updated Dec. 14, 2009
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- [2] How Bunker Busters Work - <https://science.howstuffworks.com/bunker-buster2.htm>
(Accessed 7th Mar 2020)
- [3] Ammunition & Explosives Regulations Vol 3 Pam 50 Section 2 – The Guided Weapon System
(Accessed 26th July 2020)
- [4] Eurofighter Typhoon Multirole Combat Fighter - <https://www.airforce-technology.com/projects/ef2000/> (Accessed 28th July 2020)
- [5] Ammunition & Explosives Regulations Vol 3 Pam 50 Section 3 – Missile Design (Accessed 21st July 2020)
- [6] JSP 482 Chapter 13 Para 8.3 – Storage and handling
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/198297/C13_Edt4_FINAL.pdf (Accessed 28th July 2020)
- [5] Ammunition & Explosives Regulations Vol 3 Pam 50 Section 2 – The Guided Weapon System
(Accessed 28th July 2020)

- [7] JSP 482 Chap 28 Para 1.4 – Storage and Transport of Depleted Uranium (Accessed 28th July 2020)
- [8] JSP 482 Chap 13 Para 8.7 – Storage and Handling (Accessed 28th July 2020)

FINAL GRADE

GENERAL COMMENTS

Instructor

53/100

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GRADING FORM: SMU GENERIC_GJ

STUART ATKINS

52.50

RESEARCH-INFORMED LITERATURE



regulation and functionally heavy. Environmental missing, references to explosives used missing.

5.5

KNOWLEDGE AND UNDERSTANDING



Some basic areas of understanding missing (Shaped charge function and Brisanse in particular confused.

13.5

ANALYSIS



Function means analysis would have been useful to clarify the reasons for the design option chosen being selected

17.4

PRACTICAL APPLICATION AND DEP.



The design selected was a little solutionised but there was a good appreciation of the context of the application, with some use of examples, where relevant.

11.6

SKILLS FOR PROFESSIONAL PRAC.



Needs to structure the report a little better.
Requirements-function -means - test regime.

4.5