

OME Final

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FILE	12112_LUKE_PENNY_OME_FINAL_233318_2113673613.DOCX (43.64K)		
TIME SUBMITTED	28-JUL-2020 10:03PM (UTC+0100)	WORD COUNT	2549
SUBMISSION ID	131922068	CHARACTER COUNT	13113

Principles of OME Assignment

ACDA 5010

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1. [Introduction](#)

In this report I will outline a military requirement for a guided targets/blast fragmentation bomb to be delivered by aircraft, to attack buildings of specified design. I will list all the likely requirements in the procurement phase and how the designer could meet such design requirements. I will outline all proposals for the design of materials and likely failure mechanisms. The proposed design will put through a strenuous test programme to assess hazards within the design.

2. [User requirements](#)

Certain design requirements have been put forward for a missile to perform to meet certain criteria, the requirements are that the missile to be delivered off the current delivery platform and attach at the same mounting points to avoid any additional cost to redesign a new delivery system. The missile must be able to be accurately guided to a building/bunker on the ground and penetrate the ground pre-detonation. It must cause enough damage to penetrate through the structure and incapacitate any personnel in the building.

3. [Target Platform](#)

The platform used to deliver the missile will be the F-117 Nighthawk stealth bomber. This plane has the current attachments and delivery system capable of holding the new designed article.

The aircraft can carry a range of ordnance in its weapons bay, and has the capability to house some very large munitions with massive payload. The aircraft is a stealth bomber, it doesn't rely on navigation for target acquisition, it is equipped with forward and downward looking infrared with laser-designator for target purposes and uses an inertial navigation system for flight.

The F-117 Nighthawk is integrated with a fully automated flight management system, after take-off the pilot can hand over flight control to the mission programme until within visual range of the target, the pilot can then resume control of the aircraft for the weapon delivery. The infrared acquisition and designation system are integrated with the weapon delivery system, the pilot will have a heads-up display of the target from both the forward and downward-looking infrared sensors. Weapon delivery and impact are recorded on the internal video system, this allows a real-time assessment of the dropped article. [1][2]

The plane is powered by two turbofan engines, the air intakes on both sides of the fuselage are covered by gratings which are covered with a radar-absorbent material. The plane also has areas around the exhaust which reduce the infrared and radar detectability. The two large tail fins slant outwards to provide an obstruction to the infrared and radar also. [2]

4. [Target structure](#)

The target the new missile system must defeat is a concrete clad underground bunker, the missile must have enough force to penetrate the ground and the external structure of the building before initiating. It must have enough force to crumble the structure and destroy the contents contained

within the bunker. It must be accurate upon deployment as to not miss the target which is situated beneath ground level.

5. Types of warhead

A fragmentation bomb is an explosive munition filled with a high explosive (HE) composition inside the shell. The casing of the munition can be etched or designed in a way that when the bomb detonates it will send fragments of the casing at a high velocity causing additional damage. They are usually air dropped and guided to the target below ground, they are heavy cased to increase the velocity when dropped from the air. A blast missile, is where the damage is caused by the shockwave and blast, it is also filled from a HE composition but is guided and propelled to the target, either from onboard rocket motors or from the propellant in an artillery shell. They can also cause secondary frag damage.

6. Design Parameters

The new designed article must conform with the delivery platform, this includes all design parameters and any legislation around the explosive munition;

- Weight and size/length of the munition
- NEQ mass of explosive composition
- Accurate fuzing system
- Able to withstand massive G-force and vibrations from the aircraft
- Safe to handle and manufacture
- Safe loading of the munition
- Accuracy on the target
- Climatic conditions
- Storage parameters
- All JSP's and DSA statutory guidelines

The best way of meeting these new design parameters is to look at in-service munitions that could be adapted to meet the new criteria. A design matrix such as a QFD or DFMEA will help measure up the customer requirements against the performance/cost of the new article.

7. Functionality/Design of current in-service weapon system

The current in-service GBU-28 bunker buster missile consists of a 5-meter length of hardened steel casing, filled with an explosive composition Tritonal, which is a mix of 80% TNT with 20% aluminium powder. The aluminium powder improves the brisance of the TNT, this increases the speed at which the explosive outputs its maximum pressure. This is placed within the body of the missile, the body itself is made of a dense heavy material to increase the overall mass. Attached at the front end of the barrel is a laser-guidance system. This works by a 'spotter' on the ground, who illuminates the target with a laser and the missile homes in on the highlighted spot. At the end of the assembly are

stationary fins that provide extra stability during flight. The missile is dropped from the aircraft at high altitude so that the missile develops a great deal of speed and kinetic energy at it falls, this helps with penetrating the ground surface. The missile is fitted with a delay fuze, so it explodes after penetrating the ground. [3]

8. Design options for a new weapon system

a. Shaped Charge included into the missile

A shaped charge could be included into the body of the missile to help penetrate the ground. This could help penetrate armour or reinforced buildings and direct the energy of the explosive into the surrounding building.

Potential Failure modes;

- The shaped charge might not penetrate the ground far enough for the missile to enter the structure. It could reduce the terminal velocity of the initial impact.
- When the shaped charge functions on impact, it could result in the whole function of the missile above the intended target, instead of the main explosive charge of the missile entering the building.
- The shaped charge might not function quick enough on impact for the missile to output its maximum energy into the structure.

b. Different guidance system

The use of a different guidance system could reduce the means of using a spotter on the ground to highlight the intended target. A GPS targeting system could be incorporated in the design of the munition and be guided automatically.

Potential Failure modes;

- The targeting system could fail and miss the intended target
- There could be interruption from RF/Laser that could disrupt the guidance system and the missile will not hit the intended target.

c. Increase the weight/mass of the missile

Increasing the mass of the explosive composition could increase the brissance of the TNT composition, causing more damage to the structure. The body and filled liner could be made of a denser metal, such as tungsten.

Potential Failure modes;

- This could decrease the fragmentation capability of the missile if the metal chosen for the body is too dense and doesn't break apart in uniform size upon initiation of the explosive.
- This would increase the overall cost
- Limit the number of missiles that can be carried on the aircraft

d. Different delay fuze/hard target smart fuze/computer fuze

A different fuzing system could be used in the missile. An accelerometer could be used to assess the penetration depth of the missile and a smart fuze could detonate the explosive at precisely the right time. This could increase the damage in the structure by detonating at the right place in the building to cripple the internal supports.

Potential Failure modes;

- This would increase the overall cost of the munition
- There could be interruption for RF/Laser that could disrupt the guidance system and the missile will not hit the intended target

e. Incorporate a rocket motor

A rocket motor could be used to accelerate the missile when being dropped from the aircraft. This could decrease the time in which the missile reaches terminal velocity, meaning less altitude would be required when dropping the missile.

Potential Failure modes;

- The rocket motor could fail and not increase the speed of the missile.
- The overall mass of explosive would have to be less due to the space for the rocket motor
- The rocket motor composition could be too violent and send the missile off course.

f. Diamond etched pro-liner/Incorporate tungsten balls for fragmentation.

A diamond etched pro-liner could help improve the performance of the fragmentation post detonation. It will help break the casing away from the explosive and cause regular/optimum sized fragments. An addition of tungsten balls can be added to the lining of the case to increase the fragmentation, this will also increase the overall weight of the munition.

Potential Failure modes;

- This could weaken the missile when penetrating the ground and disrupt the fuze and the main explosive fill might not detonate.
- This could decrease the number of missiles being stored on the aircraft due to weight.
- This explosive fill could be too powerful to create the desired fragment size and just vaporise the casing.

9. Chosen design criteria for new weapon system

The requirements are that the new article can be fitted onto the existing mounting platform on the F-117 plane. The current in-service design will be taken forward and adapted to achieve the desired outcome.

Main Body – The main body of the missile will stay as the current design as it has all the correct mounting points. This will be made of hardened steel to increase the overall weight. The body will still have the rear stabilising fin attached and retractable front fins behind the laser targeting system.

Explosive liner – The explosive liner will be made of a tungsten tube instead of the hardened steel, the tungsten tube will be etched with a diamond pattern to increase the fragmentation capability.

Fuze – The fuze will be a hard target smart fuse, which will allow the user to determine the depth of the munition before initiation. Computer modelling of the final design can figure out the depth penetration from the overall mass. The smart fuze will initiate once the munition has reached a certain depth or penetrating through a certain number of floors.

Explosive Composition – The explosive composition will be trialled before any suitable replacement is selected. The brisance effect from the added magnesium in the TNT is the ideal effect for tumbling buildings. Different explosives will be testing on a small scale to understand their suitability.

Guidance system – The guidance system will be laser guided, a spotter on the ground will highlight a target for the missile to hit. The fins will be able to steer the target to the ground with assistance from the guidance system.

10. [Test Programme](#)

A phased approach will be taken when testing the new missile system, to ensure it meets all the safety and performance requirements;

Phase 1 – Each component will be assessed individually for compatibility. The etched liner will be engineered to a smaller scale and filled with various explosive compositions to test performance of the fragmentation. Explosive compositions will be tested in the small-scale liner and compared; from the results the correct composition will be selected. The new explosive composition will then undergo compatibility testing with the new tungsten liner for a set period of time.

Phase 2 – The missile will be engineered with no explosive fill but an inert material of the exact same mass. The new smart fuze will be attached to the front end of the missile with the laser guidance system.

A testing range will be selected to test the performance of the ground penetration and the timing delay of the smart fuse. The missile will be air dropped from the optimum altitude onto the testing range. A highlighted area will be marked on the ground for the guidance system to track towards. Upon impact to the ground, data will be recorded on accelerometers to figure out the optimum timing for detonation in the ground. This phase will help understand the depth penetration from the new mass of the weapon and the timing for the new smart fuze.

Phase 3 – This will be to test the safety life-cycle and storage of the munition. Upon completion of the final article, it will need to undergo stringent testing before it can be commissioned. The examination will comprise of six tests;

1. *Fast cookoff*
2. *Slow cookoff*
3. *Sympathetic detonation*
4. *Bullet impact*

5. *Fragment impact*
6. *Shape charge jet impacts*

The examination will assess the ability of the munition in its storage container to withstand heat, friction, and shock. These tests are all part of the threat hazard assessment, these are requirements that must be fulfilled and passed before the new weapon system can be commissioned. These standards can be found in the Military Standard or STANAGs. [4]

11. Life-cycle

The weapon system once commissioned, is now deemed safe to store, handle, and to be loaded into the aircraft to be deployed. The weapon system will need a process in place to dispose/destroy the missile, in the event of its lengthy time in storage deteriorating or a newly commissioned item becomes available.

This can be done by either means of render safe process, which is a break down of all the components of the missile system, in turn each part can either be re-engineered or disposed of. The explosive composition can either be burned or detonated in small batches.

12. Conclusion

The new weapon system meets all the requirements set out by the customer; an existing weapon system has been adapted to enhance the performance criteria to meet the needs. This has been achieved by weighing up multiple design options and deciding on the most viable option during each phase of the trial. Computer modelling could have been used to assess the different strength and stress/strain of the metallic casing; this could save money during the trial phase. During the whole process all relevant JSP/DSA guidance has been followed in the design/procurement stage.

To fully commission a new weapon system, tests exist to determine whether munitions are likely to endure the range of storage and deployment conditions that they require to survive. It is vital to have good liaison between the customer, procurers, users, developers and manufacturers to ensure good performance and safety.

13. References

- [1] "F-117A Nighthawk," [Online]. Available: <https://www.airforce-technology.com/projects/f117/>.
- [2] "F-117A Nighthawk specifications," [Online]. Available: <http://www.angelfire.com/apes2/compclazz/page7.html>.
- [3] "How bunker busters work," [Online]. Available: <https://science.howstuffworks.com/bunker-buster.htm..>
- [4] "Army Logistical - Insensitive Munitions," [Online]. Available: https://alu.army.mil/alog/issues/JulAug06/insen_munition_tst.html.

OME Final

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

44/100

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GRADING FORM: SMU GENERIC_GJ

LUKE
PENNY

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RESEARCH-INFORMED LITERATURE



References limited to technical journals. No explosive or regulatory references

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KNOWLEDGE AND UNDERSTANDING



"Evidence of basic knowledge and understanding of the relevant concepts and underlying principles. The way these design concepts and principles interact and come together to form the system needs better explanation"

13.5

ANALYSIS



"Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. For example some of the failure modes expressed would be classified as design issues."

13.5

PRACTICAL APPLICATION AND DEP.



"An adequate awareness and mostly appropriate application of well-established methods, materials, tools and/or techniques. Some illustrations or tables to help demonstrate the understanding of some of the basic principles would help."

9

SKILLS FOR PROFESSIONAL PRAC.



"Can communicate in a suitable format but with some room for improvement. See comments earlier on construction of the report"

4

