

Data Capture & Analysis TASK 2

by John Gallacher

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**Evaluation of Data Collection and Analysis Methods from
the OME Trial**

L6 OME Degree ACDA 6021

University of Wales Trinity Saint David

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By John Gallacher

Declaration

The work of this report completed under the supervision of Gareth Collet. I declare this that this report is the product of my own work and is not being submitted for any other degree etc.

Signature:

J.Gallacher (Signed electronically)

Acknowledgement

I would like to thank all the lecturers involved at the University of Wales Trinity Saint David and COTEC for the Data Capture & Analysis module. I was provided extensive knowledge and experiences within the trial and testing industry with practical and theoretical lectures provided.

Abstract

This assignment examines the methodology and equipment used in a trial designed to identify an unknown item of Ordnance, Munition, and Explosive (OME). Since physical examination of the OME was not allowed during the trial, various data capture and analysis techniques were employed to identify the item. The report is based on the analysis of all available data to determine the nature of the OME. The primary goal of this assignment is to assess the methods utilised by Cranfield Ordnance Test and Evaluation Centre (COTEC) and University of Wales Trinity Saint David (UWTSD), identifying their strengths and weaknesses based on the results obtained. Any weaknesses uncovered will be used to explore alternative approaches and improvements for future trials. While the trial may not have provided the most credible solution due to variables such as cost, time constraints, and limited training for those involved, this report offers valuable insights into how the trial could have yielded more accurate and reliable results overall.

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1.Introduction

As part of the Data Capture & Analysis module at the University of Wales Trinity Saint David, the group was tasked with identifying an Ordnance, Munition, and Explosive (OME) item without physically seeing it. This required reliance on data capture methods and methodologies. The assignment served as a formal assessment of the various types of equipment and techniques used to identify the OME item. It also evaluated the key strengths and weaknesses of these approaches, along with alternative methods that could have been employed to improve the results.

The trial was conducted at the Cranfield Ordnance Test and Evaluation Centre (COTEC), which provided lectures, test equipment, and an arena for the assessment. While the group was involved in creating the test arena, all results obtained after the trial were submitted by a COTEC representative for evaluation purposes.

Despite the support and expertise available, the test arena was limited by factors such as time, cost, and suitability. It is important to note that the OME item was successfully identified with a justifiable argument presented in the report. However, this does not imply that the trial conducted was the only method capable of producing these results.

The writer will initially assess the equipment and methods used from the trial before identifying other means of achieving or improving these results provided by the literature and research.

2. Methods and Equipment

2.1 Methodology

To identify the Ordnance, Munition, and Explosive (OME) item, a combination of field testing and laboratory analysis was conducted. The primary focus was on measuring the velocity and blast overpressure of the munition, as these parameters provide critical insight into the explosive content and its characteristics.

The velocity of the munition fragments was recorded to allow the data to be used to calculate the energy released during detonation, which serves as a key indicator of the type and quantity of explosive material present. By comparing the calculated energy values with those found in existing literature, potential matches for the type of explosive were identified. This approach provided a strong basis for inferring the specific OME item involved.

The velocity measurement process adhered to the standard test methods outlined in the NATO Standardization Agreement (STANAG) 4439, which governs the testing of Insensitive Munitions. This ensured the testing was conducted in accordance with recognised international standards, thereby

enhancing the reliability and comparability of the results.

Following the field tests, additional laboratory analysis was conducted to further identify the materials used in the munition. These tests aimed to detect key indicators that distinguish the type of explosive used. By incorporating both field and laboratory data, a more comprehensive understanding of the OME item was achieved, strengthening the validity of the conclusions drawn.

This multi-faceted approach ensured a thorough investigation of the OME item, leveraging established methodologies and industry best practices to achieve accurate and justifiable results. This was fully overseen by suitably qualified and experienced personnel from COTEC to obtain the best results possible for the time, cost and training we had on offer.

2.2 Equipment

The methodology provided was only suitable if the ideal arrangements were in place for capturing the data. Despite the limited time, resource and experience, COTEC were able to provide lectures in how the trial would be setup and conducted while also providing reliable equipment. For the physical equipment used on the day we can assess,

Strawboard:

Since the 1960s, strawboard has been a fundamental material for intercepting fragments from explosives and explosive devices during munitions arena trials. Its reliability is supported by historical calibration to an established benchmark, enabling research institutions to estimate fragment velocity based on penetration depth.

Originally, strawboard was a readily accessible, inexpensive construction material, making it a practical choice for testing applications. However, recent economic turmoil and geopolitical supply chain disruptions have hindered its availability and driven up costs, presenting obstacles to its continued use in contemporary testing procedures [1]. This was highlighted at the test arena during the trial, COTEC opted to use previously used strawboard (See Figure 1). There are significant downsides to this however it provided a good source of material without providing a loss in revenue to the company who had offered to complete the trial.



(Figure 1- Previously used Strawboard)

The use of strawboard is highly practical, as it provides immediate physical results for examination following detonation. It serves as an effective medium for capturing fragmentation, enabling further analysis to determine the weight, size, and shape of the fragments. Additionally, the captured materials can be subjected to further laboratory testing, such as Fourier Transform Infrared (FTIR) spectroscopy, to identify the composition and properties of the materials. This process also facilitates the calculation of fragment velocity, supporting a more comprehensive assessment of the explosive event. As explosive testing generally results in toxic discharge and waste, strawboard provides a low carbon alternative to produce and manufacture allowing it a better option for the environment [2].

Despite its advantages, strawboard has become significantly more expensive over the years due to factors such as global conflicts, shifts in production, and climate change impacting the growth and harvesting of raw materials. As a result, reusing strawboard is seen as a cost-effective and resource-efficient option.

However, the reuse of previously utilised strawboard introduced some challenges. Fragments from prior trials were mistakenly identified as new fragmentations, potentially compromising the accuracy of the results. This issue could have had significant implications for the findings. Nevertheless, the expertise of on-site personnel ensured the correct identification of the materials, mitigating the impact on the overall analysis.

Velocity Foils:

Fragment velocity foils offer a reliable method for accurately measuring the velocity of fragmentation as the distance between the foil can be measured to its target. In conjunction with a Logic Analyser the velocity foils act as a very thin circuit boards which operate as a switch when conducting fragments pass through them. This is used for calculating the velocity of the fragments from their original firing point and can also be used to determine the spread and dispersion of the fragments. This process provides precise velocity data, with ease of setup as its extremely straightforward, requiring minimal equipment. It is done by taping the velocity foils to the strawboard, (See Figure 2). Once positioned at the correct distance from the test site, they can quickly and efficiently capture fragment velocities [3].



(Figure 2- Velocity Foils taped to strawboard)

One of the key advantages of velocity screens is their ability to provide real-time data. The fragment's interaction with the screens is immediately recorded, allowing for instant analysis during testing, without any delays in data processing. Additionally, these screens are non-intrusive; they simply detect the presence of fragments passing through them, ensuring that the fragmentation

process is not altered. This makes them ideal for situations where preserving the integrity of the test is crucial.

Another benefit is the cost-effectiveness of velocity screens. Compared to more advanced methods, such as high-speed cameras or sensors, velocity screens are relatively inexpensive and require less sophisticated technology, making them an economical choice for many testing facilities. Their compact and lightweight design further enhances their practicality, as they are easy to transport, set up, and store, making them suitable for various testing environments, including field and mobile testing units.

Despite their advantages, velocity screens have several drawbacks. One limitation is that they may not effectively detect smaller or lighter fragments, as these may fail to break the screens, leading to incomplete or inaccurate velocity data. Tiny or low-mass fragments may pass through without triggering the screen. Additionally, repeated use of the same screens can cause wear and damage over time, reducing their effectiveness in detecting fragments and potentially compromising the accuracy of subsequent tests

Velocity screens also provide limited data, capturing only basic velocity measurements but failing to offer detailed information about the trajectory, shape, or other characteristics of the fragments. For a more thorough analysis, additional testing methods are necessary. In cases where multiple fragments are produced, the screens may have difficulty distinguishing between them if they pass through in quick succession, which can lead to confusion and errors in velocity calculation. The fragility and sensitivity of the screens present another issue. Their thin and delicate nature makes them vulnerable to damage by high-velocity fragments, requiring frequent replacements, which can drive up maintenance costs and disrupt the testing process. Furthermore, the accuracy of velocity measurements tends to decrease over longer distances between screens, particularly in high-speed tests where fragments move rapidly. Careful calibration of the setup is essential to ensure reliable data collection over extended ranges.

Pressure Sensor:

Pressure sensors are electro-mechanical devices designed to detect forces in various gases and liquids, including compressed air, gas, vapor, oil, atmospheric/barometric pressure, pneumatic systems, water, liquids, hydraulic fluids, and corrosive media. They generate control signals that can be used to operate display devices, in this case a logic analyser [4].

The pressure sensor is surrounded by a blast pressure gauge or commonly known as the mushroom in industry for its shape (See Figure 3). The gauge is mounted this way as it splits the air and allows for a precise pressure wave passing over the sensor located in the centre of the gauge. The grey nylon bush in which the Piezoresistive sensor is in the middle of is used to reduce vibrational noise. As the blast overpressure is transporting at significantly high

pressures this causes a lot of movement in the gauges and can significantly alter the results of this test method. The nylon bush acts as a shock absorber and allows for the pressure sensor to gain accurate results while reducing vibration and velocity movements effects from foreign objects such as the stand holding the gauge in place.



(Figure 3- Blast Pressure Gauge, Steel overcover, nylon bush covering pressure sensor in the centre)

A blast pressure sensor offers several significant advantages in explosive testing and research. These sensors provide highly accurate and real-time data on the pressure generated by an explosion, which is essential for understanding the blast dynamics and its impact on surrounding materials. They can measure high-pressure levels in extreme environments, ensuring that even intense blast events are recorded with precision. The data obtained from blast pressure sensors can be used to assess the effectiveness of munitions, the performance of protective materials, and the structural integrity of objects exposed to the blast. Additionally, these sensors are relatively easy to put out and can be positioned at various points around the test site, in this example 1,2 and 3 metres away for each gauge to capture pressure variations at different distances from the explosion. This allows for comprehensive analysis of the blast wave and its effects, which is crucial for improving safety protocols and designing more effective explosive devices.

Based on experience, the sensor's sensitivity made it challenging to ensure it was properly calibrated for the trial. In the test environment, windy conditions and the constant movement of equipment led to premature readings being recorded before the explosion occurred. One limitation of pressure sensors is their non-linearity, as the output is inversely proportional to the gap between the parallel electrodes, which can lead to inaccuracies in certain measurements. Additionally, these sensors are sensitive to vibrations, which can cause fluctuations in the readings provided and affect their reliability in dynamic environments- such as the windy conditions on the day. Furthermore, material constraints can restrict the range of applications for pressure sensors, as certain materials may not be suitable for specific environments or may degrade over time when exposed to extreme conditions. Piezoresistive sensors are also not suitable for low-power or battery-operated applications due to their high-power requirements, this didn't pose a problem due to the high sophisticated facilities but was highlighted by the COTEC representative that power outages have caused loss in data countless times before in trials. Also reducing the size of the sensor also lowers its resistance, which in turn increases power consumption, making it less efficient. Additionally, the sensor's output is influenced by temperature variations, which can introduce inaccuracies and affect the reliability of the readings [5].

3. Alternative Methods

3.1 Pre-Trial

Various other methods could have been utilised during the trial. In addition to capturing the velocity foil, blast gauge and fragmentation data. Several alternative methods could have been employed to achieve better results during the trial, such as the use of **gas sensors**. These sensors would have captured the smoke released from the OME after detonation, allowing for the identification of its chemical composition. The data collected could then be compared with the results from the FTIR analysis, providing a more comprehensive assessment of the explosive used in the demonstration.

A further method of data capture would be using High-speed cameras. These play a crucial role in explosive trials by capturing ultra-fast events that are otherwise invisible to the naked eye. These cameras operate at extremely high frame rates, often thousands to millions of frames per second, allowing for the detailed analysis of the explosion's dynamics, fragmentation, and shockwave propagation.

One of the primary benefits of high-speed cameras is their ability to track the trajectory, velocity, and dispersion of fragments in real time. This data is essential for understanding the behaviour of munitions, assessing the effectiveness of explosive designs, and identifying potential hazards posed by flying debris. By reviewing frame-by-frame footage, analysts can accurately

measure fragment velocity and calculate the kinetic energy of fragments, which is critical for safety assessments and compliance with standards like NATO STANAG protocols.

This does contradict the idea of the report in not physically seeing the OME Item, however as a means of accuracy and with the trial only being completed once with no play back or means of reviewing the footage, this would have been a perfect tool to have introduced.

3.2 Post Trial

Alternative methodologies to identify an unknown explosive item can involve a variety of approaches that compliment or provide different insights compared to the traditional methods that were used in practice during the trial, such as the strawboards and velocity foils which acted as a suitable arrangement for a low cost and reliable method.

Using a more advanced technique, such as X-Ray diffraction (XRD), would have provided stronger evidence to support the report's approach. By combining traditional methodologies with modern technology, the report could have offered a more thorough and comprehensive assessment.

This analysis is a non-destructive method that delivers comprehensive information about the crystallographic structure, chemical composition, and physical properties of a material. This technique relies on the constructive interference of monochromatic X-rays and a crystalline sample. X-rays, which are a form of electromagnetic radiation with short wavelengths, are generated when electrically charged particles with sufficient energy are decelerated. In XRD, these X-rays are collimated and directed at the sample, where their interaction with the material results in a diffracted ray. This ray is then detected, processed, and counted. The intensity of the diffracted rays, scattered at various angles, is plotted to generate a diffraction pattern. Each phase of the material produces a distinct diffraction pattern, reflecting its unique chemistry and atomic arrangement. The overall diffraction pattern is simply the sum of the individual diffraction patterns from each phase [6]. This in turn would help to identify its nature and potential characteristics that were present in any of the OME items listed in the report.

Another option could be **Gas Chromatography-Mass Spectrometry (GC-MS)**, which is often used in forensic analysis to identify chemical compounds present in the explosive. This method could be effective for identifying trace chemicals or residues left behind from the explosive. From the trial there was masses amounts of residue left on the firing board in which was not assessed or considered (See Figure 3).



(Figure 3- Explosive residue left on test bed)

This technique or method is used to identify and measure chemical compounds in a sample. It works by separating the sample into its components using gas chromatography, where the compounds are carried through a column by gas and separated based on how easily they vaporise. These separated compounds then enter the mass spectrometer, where they are broken into smaller pieces and analysed based on their mass. Each compound produces a unique pattern, allowing for accurate identification. GC-MS is commonly used in forensics, environmental testing, and chemical analysis due to its precision and ability to detect even small amounts of substances. Utilising this method alongside Fourier Transform Infrared (FTIR) Spectroscopy provided by the university would further enhance the results, enabling a more thorough analysis of both the fragmentation and the remaining residue.

4. Conclusion

From the trial the methods used provided a comprehensive and acceptable argument to determine the OME Item. There was sufficient data, with additional judgments based on the expertise available. COTEC provided recognised ways of completing a trial that were relatively easy to follow and obtain an output. As the trial was setup by an inexperienced group, using older methods such as the velocity foils and strawboard was a sensible solution as it provided a means of gathering the data without the need for extensive training, safety awareness and reduced human error probability [7].

Improvements could be made to capture additional aspects of the OME item's output, such as the residue left on the firing board and the smoke produced by the explosion. To address these areas, the introduction of gas detectors and high-speed cameras has been identified as a potential enhancement. While the trial was successfully completed, several assumptions were made throughout the process. These assumptions involved narrowing down the list of possible

OME items by considering the required quantity of explosives and comparing it to the site's 10kg explosive license limit for the testing area.

The methods and data capture techniques employed provided sufficient evidence to accurately identify the munition. However, to ensure greater accuracy and validity in future trials, additional methods will be introduced. This approach aims to maintain the highest standards of precision when dealing with high-risk and hazardous items.

5. References

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Data Capture & Analysis TASK 2

GRADEMARK REPORT

FINAL GRADE

58/100

GENERAL COMMENTS

Hi John,

This was a reasonable submission gusting 2:2 with an award of 58%. I say this for the following reasons, which are better explained in the detailed comments. However, I am content that you submission meets the objectives set for the module.

Engagement with an appropriate range of research-informed literature, including sources retrieved independently. Some key referencing absent. 5/10

Knowledge is reasonably detailed, accurate with a good systematic understanding of DC&E. However, lacks depth in alternative methodologies that could be applied. 12/20

Some critical thinking, analysis, synthesis and evaluation.
An emerging awareness of different stances and ability to use evidence (that may be incomplete) to support the argument.
Mostly valid arguments and logical judgements.
Some tendency to assert/state opinion rather than argue on the basis of reason and evidence. 18/30

A good and appropriate application of standard methods, materials, tools and/or techniques.
Clear appreciation of the context of the application. Mainly consistent, accurate and logical application of theory to practice, making appropriate links between the two
Can identify problems and propose mostly appropriate solutions in complex and unpredictable contexts. 18/30

Can communicate effectively in a suitable format, but may have minor errors.

Mostly coherent, organised work, in a suitable structure and is for the most part clearly expressed. Can work effectively independently and/or as part of a team, with clear contribution to group activities.

Demonstrates the skills required in graduate employment, with some areas of strength and some of minor weakness. 5/10

In detail:

1. Make sure you spell your supervisor's name correctly in any submission, specifically the Major Project. A few minor type-o throughout e.g. page 5, first sentence of final paragraph ".....by a blast pressure gauge or commonly known as....."

2. You have no difficulty writing a good abstract. Watch for spelling - Explosive(s) in OME.

3. The content was a bit thin in terms of headings transcribed to the table of contents. Fourteen pages of Methods & Equipment without any sub-headings for the reader to refer to. You use plenty in the main text. Had you thought about using headings on strengths and weaknesses, since you introduced these in the abstract?

4. Under 2.2 Equipment, defer Strawboard to 2.2.1, Velocity Foils 2.2.2, Pressure Sensor 2.2.3 etc and use TOC which displays three levels. I note you had not separate heading for FTIR, which would have been useful to keep within its own section 2.2.4.

5. I think Figure 1 is the strawboard used below the munition after detonation. It would have been

better for you to use one of the images where the fragmentation from previous trials had been circled.

6. Under Figure 1, your next paragraph is a little confusing. You mention strawboard, then FTIR, then talk about fragmentation velocity calculation. I would presume that you mean the strawboard, not the FTIR.

7. For the velocity foils, had you thought about the problem associated with partial penetration of a fragment? This would prevent the signature of any subsequent fragmentation being detected.

8. Good observations about environmental efficiencies using strawboard AND the effect of the weather on sensor such as the pressure gauges.

9. As I read through, I note you have no heading for Alternative Methods in the Contents, AND that your contents are labelled Sections 1, 2, then 9, 10 and 11. What happened to headings 3 - 8? I see that Alternative Methods is Section 3.

10. Your first three sentences under 3.1 Pre-Trial are confusing and could have been better written. For example, the first sentence is superfluous and there should be a comma at the end of the second non-sentence. "In addition to capturing.....data, several alternative.....trail". The introduce gas sensors as 3.1.1. Then high-speed cameras under 3.1.2. However, both would have been significant force multipliers to the trial as you state.

11. OME item, not OME Item.

12. Again, split post-trail down into its sub-sub headings. What about flash x-ray of the detonation itself? Or the transition of fragmentation through space?

13. You needed a reference for the x-ray diffraction section. How would you have applied this concept to this specific trail. At the range, in the laboratory? This is not clear.

14. GC-MS is also good, but I think these methodologies should be discussed in relation to a better approach than FTIR? Perhaps a sub-heading on Chemical Analysis Improvements.

15. A well written conclusion. What about increasing the sample size of the trial from 1 firing to, perhaps, 20? What would be a good statistical methodology? Conclusion is section 4. References is Section 5. Again, refer to your contents page. Where is your Appendix?

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