

Shaped Charge Jet Mitigation Assessment.

Research proposal
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Executive summary

Contained herein is an adequate initial proposal to the provision of a project to evaluate shaped charge mitigation behaviours for the purpose of misfire disposal. Proportional assessment was made to accommodate plausible and foreseeable challenges and methodology identified to combat these and attain resilience. Declared requirements are not definite at this stage as full appraisal and examination are part of the project development. As inferred throughout requirement is subject to change to meet evolving needs of the business. Critical review of appropriate literature was undertaken in union with evidence of conventional research and development methodology.

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1 INTRODUCTION

Contained herein is a proposal for the assessment of material types for application to mitigate the effects of a hydrodynamically formed Jet; in this case fabricated through the initiation of a shaped charge.

The proposal will be used as underpinning knowledge for purposes of shaped charge jets to a disposal application to an experimental physics trial. Reasoning for the application could be but will not be limited to a misfire criterion.

This proposal gave a background to the requirements for this study, a literature review to assess common practice within the industry and methods of assessment, a proposed design statement and a measure of resource and planning to complete the project.

2 BACKGROUND

2.1 PRELIMINARY REQUIREMENTS

In the OME industry application of a shaped charge to a situation could be but not limited to experimental application and disposal purposes. The contextual application for this document stems from a question of whether an experimental setup's mitigation scheme will need to be disassembled prior to application of the donor charge to a potentially sensitised explosive. Occurrences of this could be following a misfire event for the purpose of disposal. Removal of mitigant from the line of sight will result in a compromised aperture wherein a greater risk of fragmentation, blast and other hazards will egress to the locality and its inhabitants. The proposed application of a shaped charge to this event will create a reduction in aperture size for the additional hazard and deliver a disposal event to the charge in a short timescale removing the need for interference with the trial device in an unknown state. [1, 2, 3, 4, 5.]

2.2 LITERATURE REVIEW

As standard in proposals requirement to take a measure of the industry standard in disposal methods of experimental trials was necessary. Within the remit of the search parameters across varied platforms such documentation was not available. Alternate stance was implemented in the theme of the project; methodology for disposal was assessed. This was applied to the disposal of ordnance using shaped charges, where and how they would prosper due to relativity to experimental trial mitigation schemes. The following review was executed using Google scholar, Science Direct and Semantic Scholar online repositories given the Covid – 19 pandemic limitation was experienced in access to the SA1 campus and supporting facilities at Aldermaston.

Sources were dynamically assessed to ensure funding sources could not impede the results of each study. This assessment was a subjective approach to gauge if the results could have been compromised to suit the lobby: fleeting examination yielded no clear evidence of this activity. [1]

2.2.1 PERSPECTIVE AND MEASUREMENT OF EXPECTATION

To implement a literature review; perspective was given on requirement and execution. The purpose of this study is to interrogate the application of shaped charges to explosive articles that are in an unknown condition and obscured by mitigant materials be it munitions casings, veiling by location or packaging. From research performed commonality and divergence was collated scrutinised and critically assessed.

The requirement:

- To evaluate a shaped charges application to endorse applicability to the proposals undertaking.
- To evaluate the products and assemblies used; to provide a comparator to the proposal output.
- Perform analysis of effectiveness of shaped charge application to a disposal to endorse how shaped charges were measured.

It is expected that the study will endorse the methodology of Shaped charge effectiveness measurement in disposal scenarios, their practicality and suitability in addition to the provision of comparative data for later analysis to the proposed Shaped charge product, liner, and fill.

2.2.2 LITERATURE REVIEW SCOPE AND DEFINITION

The Aim of the review is to endorse and justify the application of a shaped charge to an unknown state explosive when it is obscured from direct access to perform the application of a donor charge for

disposal. This will be contextualised through Explosive Ordnance Disposal (EOD) methodology due to literature accessibility/existence constraint. It should be acknowledged the shaped charge will be initiated whilst aimed at a target material which will represent the explosive article for disposal; the target will have a defined proximity from the charge relative to the cone diameter as a quantified form of relative proportional measurement between different sized shaped charge products.

2.2.3 COMMONALITY

Practicality of application.

Shaped charges are applied where there is obstacles to accessing the explosive this can be a piece of material obscuring the target or safety concerns leading to an unacceptable level of risk in interference with the target article [6, 7.] yet it is still common place in EOD techniques that a larger amount of donor charge is placed in close proximity or intimate contact with the target material though this methodology develops a higher order consequence than the technological application of a shaped charge due to the larger quantity of explosive material. [8, 9, 10, 11.]

Products and assemblies used and the main design principals.

Majority of applications implemented varied sizes of conical shaped charge for disposal, as alluded to in 2.2.2 shaped charges sizing is relative to cone diameter allowing proportional scalability to results for future requirement [9, 10] other shaped charge types are used within disposal and demolition of munitions such as linear shaped charges or explosively formed projectiles however suitability to this particular type of application requires a focussed shock point of initiation on the target whereas linear charges will provide a cutting mechanism and an EFP remains less effective for penetration [7, 8, 12, 13.]

Effectiveness of initiation

Target material could be encased as part of its structure or may have material in the line of sight to the explosive target: appropriate application of a shaped charge will provide the maximum penetrative effect with minimal cost and relatively less material than typical EOD technique [8, 14, 15, 16.] the effectiveness of a shaped charge jet alters over distance primarily from formation through to turbulent dispersal as distance increases providing an operational distance range an assessment will be made to relevant distancing for application. [10, 15, 17]

Effective measurement

Shaped charge effectiveness is measured through depth of penetration into a target witness material to enable endorsed estimates for residual energy following casing penetration [6, 10, 14, 18, 19, 20.] diagnostics performed on jet parameters could be in the form of flash radiography or radial streak camera though budget constraints may limit the application of such diagnostics for the purpose of disposal activity. this assessment will need to be reviewed in conjunction with the finalised requirements of the project [6, 21.]

2.2.4 DIVERGENCE

Disassembly and manual interference

It is palpable to suggest manual disassembly is a rare eventuality within recent EOD operations however to combat unacceptable risk robotics are employed for assessment of an article in an unknown state the costing relative to breakdown or error is significant and it is often there are limitations to the number of units that could be made available. In addition to the relative agility of a remotely operated tracked vehicle compared to an SQEP'd member of personnel traversing the likely complex terrain following a partial firing. [22.]

2.2.5 CLARITY OF METHOD

The application of this literature study was focussed on a comparative scenario to the proposals definition as no documentation could be made available as a direct reference.[1]

2.2.6 LITERATURE OMISSIONS AND DEFICITS IN KNOWLEDGE

Regarding disposal of an explosive trial misfire, though process exists in the initial capacity of health and safety, personnel and asset safeguarding and propagation mitigation: it cannot be suggested that a defined process to suit all eventualities could exist due to variability. Subject matter expertise, collaboration and proven methods are all considered in creating a method of disposal whilst total isolation of the article is rigorously enforced. [1, 22, 23.]

2.2.7 CONCLUSION OF REVIEW

The literature review identified it is common practice to employ a shaped charge in a disposal of a target irrespective of veiling or access constraints. A common measurement of shaped charge effectiveness was relative to the depth of penetration. The process of the review highlighted gaps in assessments of shaped charge attack to multi-layer composite veiling or mitigation obscuring the target being a mechanism of the proposed project output. [12, 22, 23.]

3 PROJECT DESIGN

3.1 PHILOSOPHY

This project will emanate factual empirical output to enable subjective judgement to be taken from a third-party interrogation. This will facilitate the output to become the foundation for forthcoming and further works.

3.2 PROJECT OUTLINE AND METHODOLOGY

3.2.1 OUTLINE

Experimental explosive trial designed and fabricated measure the depth of penetration in a target through initiation of a shaped charge assembly aimed at a series of witness plates described as the jet stack. These will be set up at varied distances holding relative proportionality to the cone diameter.

In the line-of-sight mitigation will be placed to replicate the mitigation used during an explosive trial this mitigation will vary in thickness and material type. Additional mitigation to prevent hazard egress will be implemented to contain the effects of the experiment to the trial facility without causing interference to the experiment.

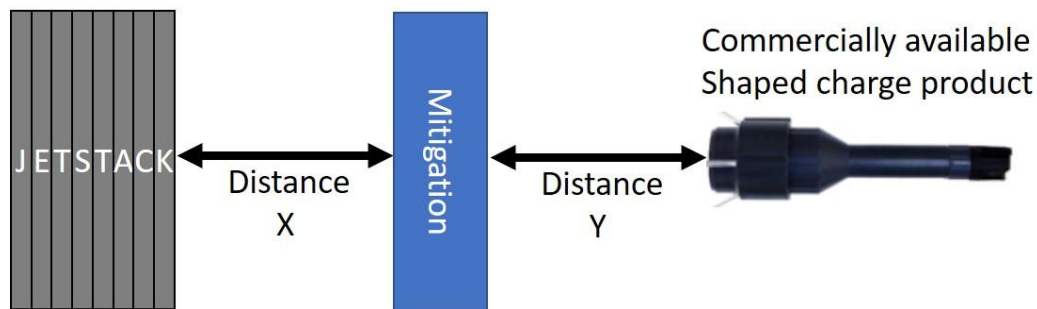


FIGURE 1 Simplistic representation of trial set up. [24]

3.2.2 FIXED PARAMETERS

Measurement should be taken of the prospective level of convolution contained within this trial design. As such constraints should be implemented to enable pragmatic and practical assessment of the trial output. Alluded to in 3.2.1. there is a significant number of parametric material and other variables that may be expedient to investigate however remaining attentive to requirement and budgetary constrain will require but not be limited to the following fixed parameters.

- Commercially available Shaped charge housing and cone assembly (pictured Vulcan Shaped charge ALFORD Technologies) once selected must remain constant through all tests.
- Commercially available plastic explosive commonly used in demolition and disposal activity to set relative costing comparator.
- Jet stack geometry, material type, finish, and assembly for consistent assessment of results

- Distance X as shown in figure 1 though a potential variable for further works an arbitrary figure will be implemented reminiscent to a legacy scenario set up, where possible geometric figures should be remnant of cone diameters.
- mitigation to prevent egress of hazard.
- initiation system
- finalised diagnostics
- operational facility or range

through project maturity there may come precedence to add or remove fixed variables from this list to meet business requirement.



FIGURE 2 The Late Dr Sydney Alford demonstrating the Vulcan at UKPS AGM [25]

3.2.3 VARIABLES

Limitation to variables to contain complexity of the experiment have been implemented, rationale to this is biased on the researcher's interpretation of preliminary requirement and familiarity driven relevant selection of necessary variables.

- Mitigation material will be employed in relative sizing to those commonly available to mitigate the effect of hydrodynamic trials, primarily 'mitigation boxing' Aluminium steel and soda glass are suggested as material types.
- Alternate sizing of different material types will be trialled to enable a range of operation for the shaped charge assembly.
- Within time and budgetary constraint potential for distance Y alteration may become viable for assessment however this variable will effectively require a repeat of all tests up to this point

Project execution will define the requirements variability in the trial framework and remains subject to alteration in accordance with business requirement.



FIGURE 3 Wooden mitigation trial set-up [26]

3.2.4 METHODOLOGY

As is standard for explosives trial standard procedure will be followed for the lifecycle of the trial from concept to fruition and reporting.

3.2.5 DATA ACQUISITION

A formal assessment to rationalise diagnostic fielding will be commenced in line with available budgetary constraints.

For the objectives to be met

- Safe system of work will be produced to allow repeatability of the experiment and shaped charge assembly.
- Review and learning initiatives will be employed to consider the practicality of application and potential limitations to achieving this.
- The primary diagnostic in the trial will be the depth of penetration into the jet stack.
- Additional diagnostics may be employed should there be an evolving business requirement these could be in the form of optical or radiographic diagnostic techniques.

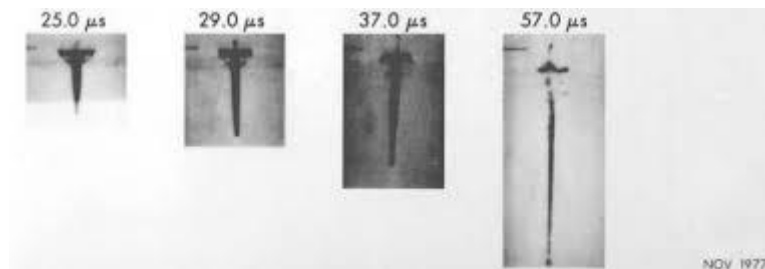


FIGURE 4 Shaped charge collapse [27]

3.2.6 SCOPE FOR ADDITIONAL WORK

Given the restraint observed within the variables and diagnostic employed to this project there is substantial scope for further work to fully define the operation of a shaped charge driven disposal of an unknown state explosive obscured by mitigation. Following the yield of expected results multilayer composite mitigation would be the researchers preferred direction of work.

3.3 RISK AND LIMITATION

3.3.1 RISK AND LIMITATION IDENTIFICATION

Risk and limitation remain a viable threat to the completion of the project; to appropriately assess risks at this preliminary staging an over arching assessment was made to identify top level categories that may suffer failure or conflict in a myriad of ways. It was evident that the top-level category for latter assessments were:

- Primary resource.
- Adequate and scoped planning.
- Established priority for the project.
- Commercial or professional commitments.

In addition to above risk and limitation can be presented in personal lives of not only the researcher but other key personnel key in the realisation of the project and some dedication should be made to implementation of a resilience plan as inferred within both resource and planning.

3.3.2 LEGAL

There are no defined legal ramifications with the execution of this trial within the bounds of regulated premises following the guidance set out by ER2014 and ER2014 amendment 2016. Primary legal risk stems from the potential risk to Environment safety and health (ESH) in accordance with the health and safety at work regulations 1974 and subordinate specialist regulation and guidance. In order to combat this ESH procedure and processes will be followed partially in the form of an approved Safe System of work including but not limited to method statements and risk assessments.

3.3.3 ETHICAL

To operate ethically the researcher will operate within the boundaries of:

- Researcher's company blueprint [28]
- Institute of Explosive Engineers code of conduct [29]
- UWTSD Research Ethics & Integrity Code of Practice [30]
- UWTSD Research Data Management Policy [31]

In addition, a formal application will be made to the university in accordance with their procedure. It should be stated that no social element to the activity will be formally assessed and under the boundaries of the aforementioned legal constraint no vulnerable persons will be subject to involvement in this project.

3.4 DELIVERABLES

Deliverables are an adequate measure of success within a project coming to fruition, for this project's aim a series of staged gates will emanate in the following output being realised:

- Delivery of experiment
- Report and analysis of results
- Process guidelines contained within the report to enable comparative measurement for future works.
- Framework for evaluation of application of a specified commercial shaped charge assembly to the disposal of a compromised trial assembly
- Potential Hydrocode endorsement dependant on diagnostics fielded.

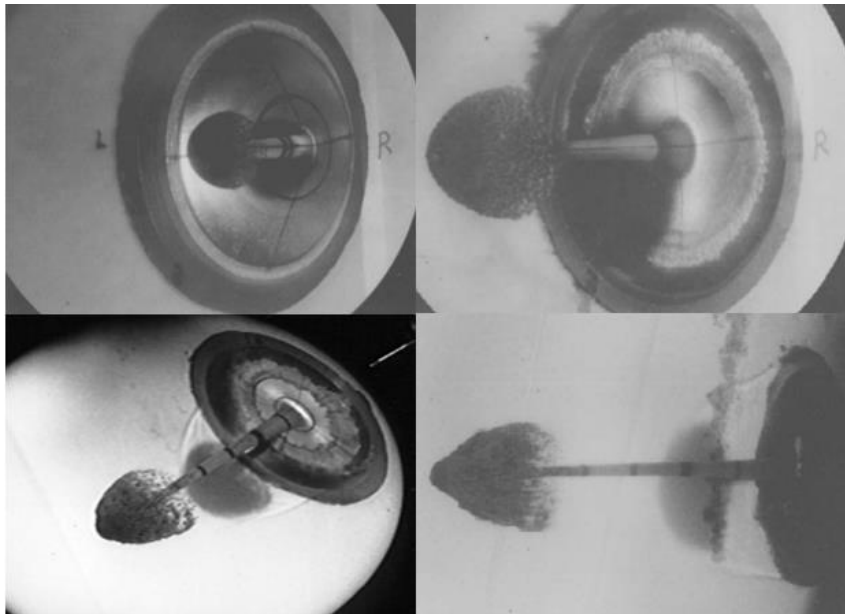


FIGURE 5 Demonstration of hydrodynamic behaviour during a Shaped charge firing [27]

4 RESOURCE

4.1 OVERVIEW

There is necessity to identify the resources required to enable realisation of this project not only to determine any risk or limitation attached to the resource but to adequately prepare the resource and plan its commitment to the project's delivery and proficiently deconflict or redirect resource to empower successful and effective delivery throughout the progression of project delivery.

4.2 TABLE OF INFERRED RESOURCES

Primary resource (integral)	Secondary resource (can be changed)
Researcher	Operations personnel
Business requirement	Facility
Processes and paperwork commitments	Explosive supply
Design approvals	Shaped charge assembly
Safety requirements and approvals	Physical component suppliers/manufacturers
Stakeholders	Material supply
Planning and deconfliction	
IT infrastructure and software	

5 PLANNING

5.1 OVERVIEW

As indicated within resource adequate planning is absolute in the delivery of any piece of work. Improper execution of planning activity in its simplest meaning will undermine most deliveries. In the purest sense it is suggested that the project will span a 2-year period suggesting a quarterly approach to execution culminating in biannual staged gates to be met.

5.2 TIMELINE CONSIDERATION

Within planning consideration should accommodate 3 scoped timelines to enable overrun and overperformance. This methodology of optimistic realistic and pessimistic planning timelines allows scope for movement within the realistic plan and directs the researcher where priority and time can be proverbially bought back and future activity deconflicted. 5.3 demonstrates this as an arbitrary infographic Gant chart.

5.3 SIMPLE GANT CHART

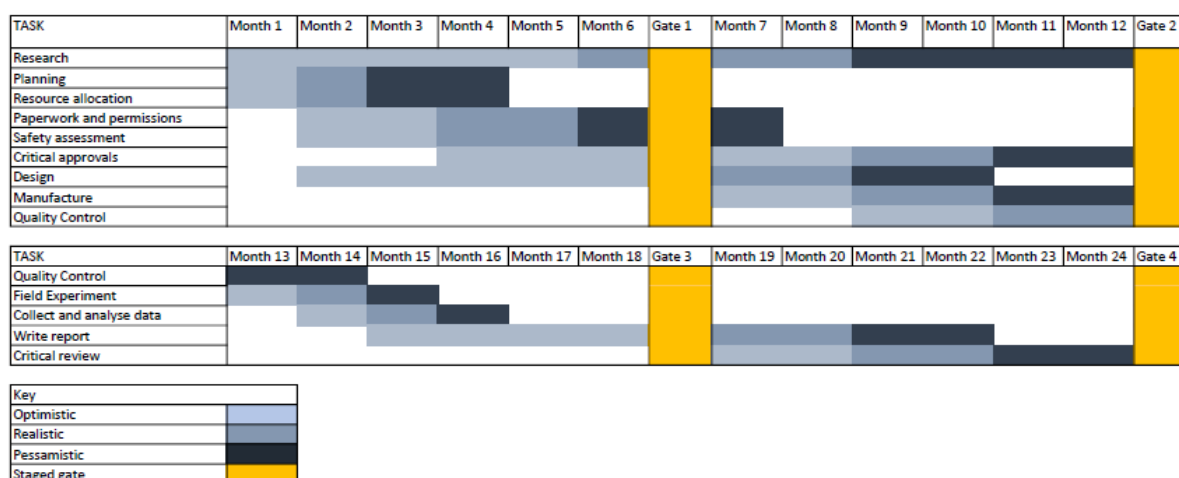


FIGURE 6 Arbitrarily scoped Gant Chart demonstrating "Scoped planning".

6 CONCLUSION

6.1 PROPOSAL CONCLUSION

Through proportional evaluation it was evident that adequate initial assessment has been made to the execution of this proposed project. Critical review of relevant literature was undertaken in conjunction with demonstration of typical research and development methodology. Final requirements are not confirmed at this stage as full assessment and interrogation are part of the project process. As inferred throughout requirement is subject to change to meet evolving needs of the business. Significant measure and investment was made to accommodate plausible and foreseeable challenges and methodology identified to combat these and attain resilience.

6.2 NEXT STEPS

Trial lifecycle management procedure will be followed in the execution of this project upon approval.

6.3 REVIEW OF ACTIVITY

Approach to this proposal was contextually misaligned, additionally additional commitment to work activity took precedence in the delivery of this proposal. Reflection would highlight obligation to contextualise the modules delivery direction to harmoniously align with OME type projects within the delivery brief. Reactive support was given by the lecturer to better align the course delivery within the bounds of their authorised and ethical capacity. Time management methodology was imparted however time bound commitments took priority.

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