

Major Project Proposal

by Oliver Overton

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University of Wales Trinity St David

An investigation into the effects of material properties Vs physical changes when modelling shaped charges.

Project Proposal

Student ID: 1910610

Student: Oliver (Olly) Overton

Contents:

Introduction... **3)**

Aims and objectives... **3)**

Background to the project/Literature review... **3)**

Project design... **4)**

Resources and planning... **5)**

References... **5)**

Appendix... **6)**

Introduction:

The modelling of shaped charges involves many components, which work holistically and contribute a significance to the end output of the simulation. When delving into the many components that affect the performance of a shaped charge, the components can be categorised as either, material properties or physical changes in the setup of the simulation. It is unknown what components carry the most significance in altering the end output of a simulation. Therefore, a study into the magnitude of each individual component is required to determine its importance in the model.

Aims/Objectives:

The aim for this project is to develop a hierarchy-based dataset, which will be able to inform the larger community when modelling experimental setups.

Objectives to achieve this include:

- Validate a model from data collected on trial testing shaped charges.
- Determine a list of major components that affect a shaped charge simulation.
- Alter these components within a pre-defined range.
- Calculate the penetration change into a block of RHA (Rolled Homogeneous Armour).
- Produce a hierarchy of the components and analyse their significance into the penetration of RHA in a simulation.

Background to the project/Literature review:

When modelling the possible components that affect shaped charge simulations, a hydrocode is used. Hydrocodes calculate the fluid flow of systems by splitting up the systems into a three-dimensional matrix of sub-cells and calculating the interactions of the forces between them [1].

It is fairly common practice to run high fidelity simulations, such as those using hydrocode or Finite Element Analysis software in a deterministic fashion, whereby a single simulation is undertaken, from which a single solution is obtained. In most cases these simulations are for perfect geometries, based on CAD or design packs and assigned library values for material properties, which may or may not be representative of the physical device they are meant to be replicating.

For devices such as shaped charge warheads, it is proposed that small changes in physical parameters, such as material properties or liner geometry can have a large effect on the penetrative capacity of the charge. It is therefore beneficial to understand the sensitivity of the warhead output (such as tip velocity, jet length, particulation time etc.) to these small variations in the inputs in order to provide more informed answers on the possible penetrative capacity of the warhead.

A study on internal blast loading looked at the way; tunnel diameter, liner thickness, overburden depth and mass of explosive, affected the pressure produced in a tunnel and the resulting damage this caused. However, the study also looked at how Coupled-Eulerian-Lagrangian mesh would affect the results, as well as using different equations of states for the plasticity of concrete. Therefore, this study is somewhat similar to mine, in the sense that both material properties and physical parameters were altered to explore the end result. The difference with this study is that the focus was solely on the damage to unlined vs lined tunnels, whereas I would be looking at how the different modelled factors affected these end results [2].

After looking at a variety of journal articles that had a connection to explosive modelling [3] [4] [5], I decided to get more specific and focus on studies where shaped charges were analysed in depth.

A study on the influence of the radius of the liner, on the jet formation taught me that the jet formation itself will have to be heavily focussed on. This is because the transitional phase from solid to plasma (almost liquid) in a model can heavily affect penetration performance. This would also affect the penetration characteristics [6]. The level of science in this piece of work is really in depth and uses some newly developed formulas to work out properties of shaped charges. However, there is no mention of the jet break up. A big part of the jet formation is how the plasma breaks up into pieces. I know from previous work on trials at Dstl that the breakup is one of the most significant factors relating to penetration.

In order to prepare for my final project, I researched many theses [7] [8] [9] on shaped charge performance and what can be done to improve this. This gave me a broad but yet in depth capability, to start listing components that affect penetration; both physical and material.

Project design:

Before any research of my own can be carried out, I will first need to setup a validated shaped charge simulation. This will involve using data I have previously collected out on range of a small shaped charge named K4. Once I can produce a model that accurately reflects the data collected from a trial, I can start to alter the components, then analyse their significance when it comes to affecting the charges performance.

One way of undertaking such analysis is to employ a probabilistic approach, whereby distributions are applied to input variables within reasonable bounds, for example liner yield strength or explosive detonation velocity, and a number of simulations with these varied input are undertaken using the Monte Carlo method from which a distribution of outputs is obtained.

Initially the sensitivity to variation in material property parameters will be investigated, such as:

- Yield strength of liner
- Melt temperature of liner
- Strain rate sensitivity of liner
- Hardening parameter of the liner
- Explosive detonation velocity

This will be followed by, geometrical variations and the effect of warhead asymmetry.

In order to analyse the data from these simulations I will use tracers. Tracers are not physical material in a simulation, but a theoretical data point that records data in that region. I will be able to record velocity, mass of the jet, jet break-up and penetration using these tracers.

Limitations in this study will be the degree of accuracy of the software. For a start, a simulation will produce the same result each run. Whereas, in real life multiple shaped charge firings will give multiple varied results. To combat this I will take an average of a large dataset to be used to validate my model.

Resources/Planning:List of deliverables:

- 1) Dataset collated from previous shaped charge trials conducted by Dstl.
- 2) Validated model that represents said data from the trials.
- 3) A list of all components that affect shaped charge performance, and the research behind each one.
- 4) Matrix of simulations to be ran, to be then filled with penetration data.
- 5) A report on my findings.

Please find a completed gantt chart (1) of time management in the appendix of this report.

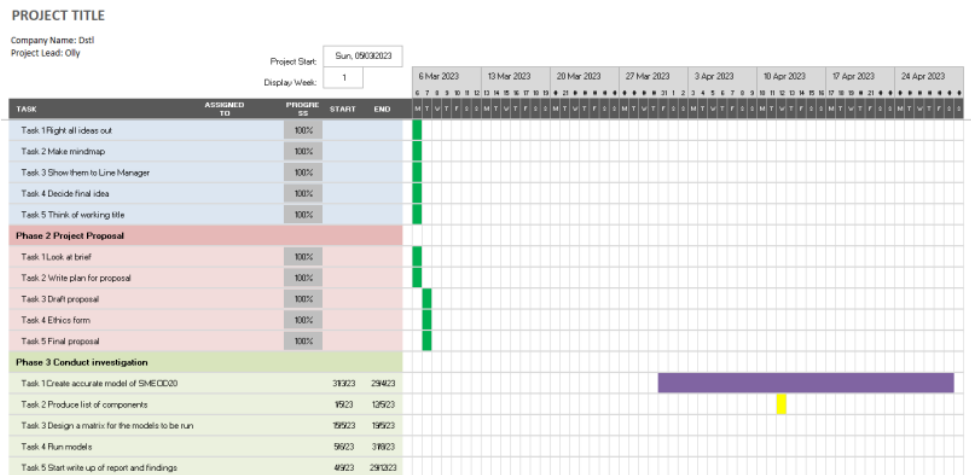
Please find the completed ethics form (2) in the appendix of this report.

References:

- [1] Y. Chang, "Hydrocode Analysis at APL," John Hopkins, 1998.
- [2] M. & S. M. R. Zaid, "Advances in computational design," *Numerical modelling of internal blast loading on a rock tunnel*, vol. 5, no. 4, pp. 417-443, 2020.
- [3] A. Remennikov, "Modelling blast loads on buildings in complex city geometries," Cranfield University, 2005.
- [4] J. G. & N. C. A. & J. M. R. Rasico, "International Journal of Vehicle Performance," *Modelling Fragmentation of a 155 Mm Artillery Shell IED in a Buried Mine Blast Event*, vol. 4, no. 4, 2018.
- [5] N. Whitworth, "Mathematical and Numerical Modelling of Shock," Cranfield University, 2008.
- [6] A. Gustafsson, "Shaped Charge Design," Karlstads University, 2021.
- [7] S. Saran, "Experimental Investigations on Aluminum Shaped Charge Liners," Elsevier Ltd, Ankara, 2013.
- [8] H. Agu, "The effects of 3D printed material properties on shaped charge liner performance," Cranfield University, 2019.
- [9] A. Meegan, *Shaped Charge Analysis*, Sandia National Libraries, 2018.

Appendix:

1) Gantt chart.



2) Completed Ethics form.

SECTION A: About You (Principal Researcher)

1	Full Name:	Oliver (Olly) Overton
2	Student Number:	1910610
3	Email address:	1910610@student.uwtsd.ac.uk
4	Programme of Study:	OME Apprenticeship Degree
5	Director of Studies/Supervisor:	Kapilan

SECTION B: Internal and External Ethical Guidance Materials

	Please list the core ethical guidance documents that have been referred to during the completion of this form (including any discipline-specific codes of research ethics, location-specific codes of research ethics, and also any specific ethical guidance relating to the proposed methodology). Please tick to confirm that your research proposal adheres to these codes and guidelines. You may add rows to this table if needed.	
1	UWTSD Research Ethics & Integrity Code of Practice	☒
2	UWTSD Research Data Management Policy	☒

3	Dstl Permission To Publish	☒
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SECTION C: Details of Research Activity

1	Indicative title:	An investigation into the effects of material properties Vs physical changes when modelling shaped charges		
2	Proposed start date:	31/03/2023	Proposed end date:	22/03/2024
Introduction to the Research (maximum 300 words in each section) Ensure that you write for a <u>Non-Specialist Audience</u> when outlining your response to the three points below: • Purpose of Research Activity • Proposed Research Question • Aims of Research Activity • Objectives of Research Activity Demonstrate, briefly, how <u>Existing Research</u> has informed the proposed activity and explain • What the research activity will add to the body of knowledge • How it addresses an area of importance.				
3	Purpose of Research Activity To find what components in a simulation contribute the greatest significance to the end result, when modelling a shaped charge.			
4	Research Question What components affect the penetration of a shaped charge the most?			
5	Aims of Research Activity The aim of this work is to validate a model from previous data, then run a series of models from a matrix that will be pre-defined by myself.			
6	Objectives of Research Activity • Produce an accurate simulation of the SMEOD20 charge. • Produce a list of all components affecting penetration of a charge. • Run simulations and capture the velocity, jet break-up, penetration • Produce an end report with supporting hierarchy.			
Proposed data collection methods (maximum 600 words)				
7	Using hydrocode software and tracers in the models. Using trials data from previous trials I have partook in.			

SECTION D: Scope of Research Activity

	Will the research activity include:	YES	NO
1	Use of a questionnaire or similar research instrument?	☐	☒
2	Use of interviews?	☐	☒
3	Use of focus groups?	☐	☒
4	Use of participant diaries?	☐	☒
5	Use of video or audio recording?	☐	☒
6	Use of computer-generated log files?	☒	☐
7	Participant observation with their knowledge?	☐	☒
8	Participant observation without their knowledge?	☐	☒
9	Access to personal or confidential information without the participants' specific consent?	☐	☒
10	Administration of any questions, test stimuli, presentation that may be experienced as physically, mentally or emotionally harmful / offensive?	☐	☒
11	Performance of any acts which may cause embarrassment or affect self-esteem?	☐	☒
12	Investigation of participants involved in illegal activities?	☐	☒
13	Use of procedures that involve deception?	☐	☒
14	Administration of any substance, agent or placebo?	☐	☒
15	Working with live vertebrate animals?	☐	☒
16	Procedures that may have a negative impact on the environment?	☐	☒
17	Other primary data collection methods. Please indicate the type of data collection method(s) below.	☒	☐
	Flash x-ray images of shaped charges.		

If you have ticked NO to every question then the research activity is (ethically) low risk and you may skip section E and continue to section F.

If YES to any question, then no research activity should be undertaken until full ethical approval has been obtained.

SECTION E: Intended Participants

Who are the intended participants:		YES	NO
1	Students or staff at the University?	☐	☒
2	Adults (over the age of 18 and competent to give consent)?	☐	☒
3	Vulnerable adults?	☐	☒
4	Children and Young People under the age of 18? (Consent from Parent, Carer or Guardian will be required)	☐	☒
5	Prisoners?	☐	☒
6	Young offenders?	☐	☒
7	Those who could be considered to have a particularly dependent relationship with the investigator or a gatekeeper?	☐	☒
8	People engaged in illegal activities?	☐	☒
9	Others. Please indicate the participants below, and specifically any group who may be unable to give consent.	☐	☒
Details of any other participant groups:			
(this box should expand as you type)			

Participant numbers and source		
Provide an estimate of the expected number of participants. How will you identify participants and how will they be recruited?		
10	How many participants are expected?	N/A
11	Who will the participants be?	N/A
12	How will you identify the participants?	N/A

	Information for participants:	YES	NO	N/A
13	Will you describe the main research procedures to participants in advance, so that they are informed about what to expect?	☐	☐	☒
14	Will you tell participants that their participation is voluntary?	☐	☐	☒
15	Will you obtain written consent for participation?	☐	☐	☒
16	Will you explain to participants that refusal to participate in the research will not affect their treatment or education (if relevant)?	☐	☐	☒
17	If the research is observational, will you ask participants for their consent to being observed?	☐	☐	☒
18	Will you tell participants that they may withdraw from the research at any time and for any reason?	☐	☐	☒
19	With questionnaires, will you give participants the option of omitting questions they do not want to answer?	☐	☐	☒
20	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	☐	☐	☒
21	Will you debrief participants at the end of their participation, in a way appropriate to the type of research undertaken?	☐	☐	☒
22	If NO to any of above questions, please give an explanation			
	<i>(this box should expand as you type)</i>			

	Information for participants:	YES	NO	N/A
24	Will participants be paid?	☐	☐	☒
25	Is specialist electrical or other equipment to be used with participants?	☐	☐	☒
26	Are there any financial or other interests to the investigator or University arising from this study?	☐	☐	☒

27	Will the research activity involve deliberately misleading participants in any way, or the partial or full concealment of the specific study aims?	☐	☐	☒
28	If YES to any question, please provide full details			
	(this box should expand as you type)			

SECTION F: Anticipated Risks

	Outline any anticipated risks that may adversely affect any of the participants, the researchers and/or the University, and the steps that will be taken to address them.	
	Risks to participants	
1	For example: sector-specific health & safety, emotional distress, financial disclosure, physical harm, transfer of personal data, sensitive organisational information. If you have identified in section D that there are no participants then enter N/A and go skip to question 3.	
	Risk to participants: N/A	N/A
2	If research activity may include sensitive, embarrassing or upsetting topics (e.g. sexual activity, drug use) or issues likely to disclose information requiring further action (e.g. criminal activity), give details of the procedures to deal with these issues, including any support/advice (e.g. helpline numbers) to be offered to participants. Note that where applicable, consent procedures should make it clear that if something potentially or actually illegal is discovered in the course of a project, it may need to be disclosed to the proper authorities	
	N/A	
	Risks to the investigator	
3	For example: personal health & safety, physical harm, emotional distress, risk of accusation of harm/impropriety, conflict of interest	

	Risk to the investigator: Risk of physical harm from electronics, energetic materials, slips, trips, manual handling and adverse weather conditions.	<i>How you will mitigate the risk to the investigator:</i> Risk assessments will be undertaken prior to any work. Only trained personnel, as defined by ESA NOS, will be allowed to handle energetic materials. I am competently signed off for the ESA/NOS process.
4	University/institutional risks For example: adverse publicity, financial loss, data protection	
	Risk to the University:	<i>How you will mitigate the risk to the University:</i>
5	Environmental risks For example: accidental spillage of pollutants, damage to local ecosystems	
		<i>How you will mitigate the risk to environment</i>

SECTION G: Feedback, Consent and Confidentiality

If you have identified in section D that there are no participants then enter skip this section and continue to section H.

1	Feedback What de-briefing and feedback will be provided to participants, how will this be done and when?
	N/A

2	Informed consent Describe the arrangements to inform potential participants, before providing consent, of what is involved in participating. Describe the arrangements for participants to provide full consent before data collection begins. If gaining consent in this way is inappropriate, explain how consent will be obtained and recorded in accordance with prevailing data protection legislation.
	N/A
3	Confidentiality / Anonymity Set out how anonymity of participants and confidentiality will be ensured in any outputs. If anonymity is not being offered, explain why this is the case.
	N/A

SECTION H: Data Protection and Storage

	Does the research activity involve personal data (as defined by the General Data Protection Regulation 2016 "GDPR" and the Data Protection Act 2018 "DPA")?	YES	NO
1	"Personal data" means any information relating to an identified or identifiable natural person ('data subject'). An identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person. Any video or audio recordings of participants is considered to be personal data.	☐	☒
	If YES, provide a description of the data and explain why this data needs to be collected:		
2	(this box should expand as you type)		
	Does it involve special category data (as defined by the GDPR)?	YES	NO
3	"Special category data" means sensitive personal data consisting of information as to the data subjects' – (a) racial or ethnic origin, (b) political opinions, (c) religious beliefs or other beliefs of a similar nature, (d) membership of a trade union (within the meaning of the Trade Union and Labour Relations (Consolidation) Act 1992),	☐	☒

	(e) physical or mental health or condition, (f) sexual life, (g) genetics, (h) biometric data (as used for ID purposes),		
	If YES, provide a description of the special category data and explain why this data needs to be collected:		
4	(this box should expand as you type)		

	Will data from the research activity (collected data, drafts of the thesis, or materials for publication) be stored in any of the following ways?	YES	NO
5	Manual files (i.e. in paper form)?	☒	☐
6	University computers?	☐	☒
7	Private company computers?	☒	☐
8	Home or other personal computers?	☐	☒
9	Laptop computers/ CDs/ Portable disk-drives/ memory sticks?	☒	☐
10	"Cloud" storage or websites?	☒	☐
11	Other – specify:	☐	☒
12	For all stored data, explain the measures in place to ensure the security of the data collected, data confidentiality, including details of backup procedures, password protection, encryption, anonymisation and pseudonymisation:		
	All data will be captured using encrypted "standalone machines" on a closed network. (this box should expand as you type)		

Data Protection			
	Will the research activity involve any of the following activities:	YES	NO
13	Electronic transfer of data in any form?	☒	☐
14	Sharing of data with others at the University outside of the immediate research team?	☐	☒

15	Sharing of data with other organisations?	☐	☒
16	Export of data outside the UK or importing of data from outside the UK?	☐	☒
17	Use of personal addresses, postcodes, faxes, emails or telephone numbers?	☐	☒
18	Publication of data that might allow identification of individuals?	☐	☒
19	If YES to any question, please provide full details, explaining how this will be conducted in accordance with the GDPR and Data Protection Act (2018) (and/or any international equivalent):		
	All data will be captured using encrypted "standalone machines" on a closed network. <i>(this box should expand as you type)</i>		
20	List all who will have access to the data generated by the research activity:		
	Principal researcher: Oliver Overton Lead Technical Reviewer University Supervisor		
21	List who will have control of, and act as custodian(s) for, data generated by the research activity:		
	Principal researcher		
22	Give details of data storage arrangements, including security measures in place to protect the data, where data will be stored, how long for, and in what form.		
	All data will be captured using encrypted "standalone machines" on a closed network. <i>(this box should expand as you type)</i>		
22	Confirm that you have read the UWTSD guidance on data management (see https://www.uwttd.ac.uk/library/research-data-management/)	☒	
23	Confirm that you are aware that you need to keep all data until after your research has completed or the end of your funding	☒	

SECTION I: Declaration

	The information which I have provided is correct and complete to the best of my knowledge. I have attempted to identify any risks and issues related to the research activity and acknowledge my obligations and the rights of the participants. In submitting this application I hereby confirm that I undertake to ensure that the above named research activity will meet the University's Research Ethics and Integrity Code of
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	Practice which is published on the website: https://www.uwtsd.ac.uk/research/research-ethics/		
1	Signature of applicant:	x 	Date: 05/03/2023
2	Director of Studies/Supervisor:		Date:
3	Signature:		

FOR INTERNAL USE ONLY:

	Ethical approval given		
1	Signature of assessor:		Date:
2	Name:		
3	Role:		

Major Project Proposal

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

65/100

Intro / Aim & Objectives (150 words)		
Project title.		
Identification of a specific problem to be investigated.		
Well-defined aims and SMART objectives.		
Explaining why this project is worth doing.		
Discussion of what the project needs to do in order to be a success.		
Description any deliverables that will be produced at the end of the project	20	10
Topic area been identified and discussed but is somewhat lacking in detail. Reasonable aims and objectives suggested however the objectives are vague in some of the SMART aspects. Try include some more detail on the specificity and measureability. Deliverables have been mentioned. Success criteria could benefit from being discussed in this section in more detail.		
Background to the Project / Literature Review (450 words)		
Description of how the work to be done in the project relates to the work identified in the literature review.	20	15

Discussion of any ethical issues raised by the project Identifying what has already been done within the field. Topic familiarity. Brief literature review using appropriate sources – 6-8 journal papers and book chapters rather than just websites. Selection of relevant models & concepts. Good demonstration of topic familiarity. Some diagrams of currently accepted setup or examples of a worked calculation may have been beneficial in this section. A range of references have been used and for the most part are recent and relevant, a few are quite dated by this point so try and stick to publications within the last five years where possible. IEEE correctly used throughout.		
Project Design (200 words)		
Clear statement of which development methods are to be used and why they are appropriate. Clear statement of which tools are to be used and why they are appropriate. Clear description of how data collected will be analysed Project plan is detailed with appropriate methods selected. Avoid using the first person, consider “tracers will be used” instead of “I will use tracers”, etc.	30	24

Good consideration of limitations for this research.		
Resources / Planning (200 words)		
List of any deliverables. Clear diagram showing both timing and resource use. Completed ethics form. Limited and relevant appendices A comprehensive list of deliverables has been provided, very good. More information on the materials required for this project would have been helpful at this point. Gantt chart has been included, however it appears to be lacking in detail. Some of the tasks have no time scale and there are large periods of time that have no activity. Completed ethics form has been included, this would have benefitted from being a separate appendix to gantt chart as it is a separate document, this could then have been listed in the table of contents as "Appendix A – Gantt Chart" and "Appendix B – Completed Ethics Form".	15	7
Document Presentation		
Correct spelling. Grammar and punctuation. Flow of narrative/fluency. Coherence.	15	9

Word processed. Correct use of referencing with bibliography. Strict word limit for main text – 1000 words. Spelling and grammar correct throughout. Good narrative flow. Avoid the use of first person, try using phrases such as “the researcher” instead of “I” to maintain a third person narrative. Kept within the wordcount +/- 10%		
TOTAL	100	65

PAGE 1
PAGE 2
PAGE 3
PAGE 4
PAGE 5
PAGE 6
PAGE 7
PAGE 8
PAGE 9
PAGE 10
PAGE 11

