

Major Project Proposal - Samuel Page (1910580)

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An Investigation on the effects of multi-layer charge liners on EFP formation and performance

Research Proposal

Samuel Page

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Figure 2 - Tandem EFP Formation, Simulation, and Imagery

Tables

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Abbreviations

SC – Shaped Charge

EFP – Explosively Formed Projectile

COTEC – Cranfield Ordnance Test and Evaluation Centre

ERA – Explosively Reactive Armour

AT – Anti-Tank

AS – Anti-Structure

DLSC – Dual-layer Shaped Charge

APV – Armoured Personnel Vehicle

PE4 – Demolition Plastic Explosive 4

TBC – To be confirmed

CD – Cone Diameters

XO – X-ray Operator

RPS – Radiation Protection Supervisor

Cu – Copper

UWTSD – University of Wales Trinity Saint David

TCO – Trials Conducting Officer

1. Introduction

Previously, research has been carried out on the use of dual layered SC liners to either enhance penetration or to enhance behind armour effects [1]. An example is shown in Figure 1. Extensive research has been conducted on SCs, however, there is a limited amount of research on dual liner EFP warheads. EFPs can be used for a wide range of applications so to fill a gap in knowledge, this research will begin to form an understanding of the effect these multi-layer liners have on EFP formation and performance. It is believed that the penetration ability will be enhanced, however, this research should inform an understanding of the effect and limitations to this technology.¹

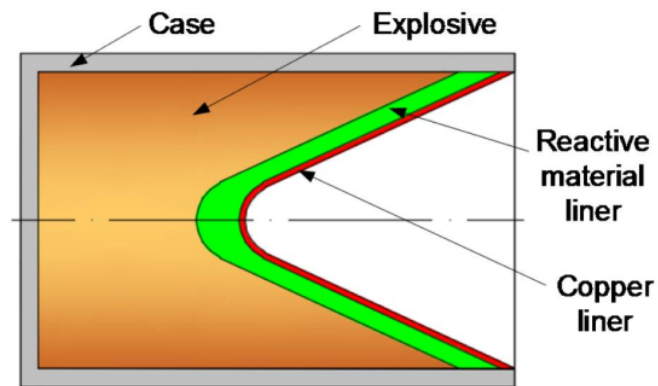


Figure 1 - Diagram of a dual-layer liner for Shaped Charges [2]

¹ This research will also provide COTEC with the ability to conduct future research projects and will assist with the commissioning of a new digital x-ray imaging system.

2. Background to the Proposed Research

With the increasing number of concrete structures and the up armoured of combat vehicles with defences such as ERA, there has been a focus on improving the penetration performance of AT and AS munitions such as SCs and EFPs [3]. There have been many approaches to SCs such as the addition of multi-layered liners with a sintered reactive secondary layer on an outer non-reactive copper liner [4]. Another way of trying to enhance the penetration performance of SCs was to develop a DLSC. This has a co-axial high velocity of detonation explosive encasing a low velocity of detonation explosive overdriving the detonation due to interference of the shock waves [5]. Replication was difficult however, due to the particulation of the SC jet [5]. Due to the limited number of warheads utilising EFPs, few research projects have been carried out to understand how multiple layered liners might affect the EFP formation and penetration. EFP warheads have been used to great effect on structures and APVs in conflicts such as Iraq [6]. EFPs also exhibit much greater stability and penetrative ability over much greater standoffs than SCs [6].

Some limited simulation works using AUTODYN-3D and LS-DYNA have been carried out to simulate the effects of having layered EFP liners and have shown the potential for a tandem penetrator arrangement to form with the front EFP travelling at greater speeds to the EFP following behind [3]. With limited experimental work having been carried out and poor imagery of the EFP, it can be difficult to understand why this velocity difference exists. This is shown in Figure 2.

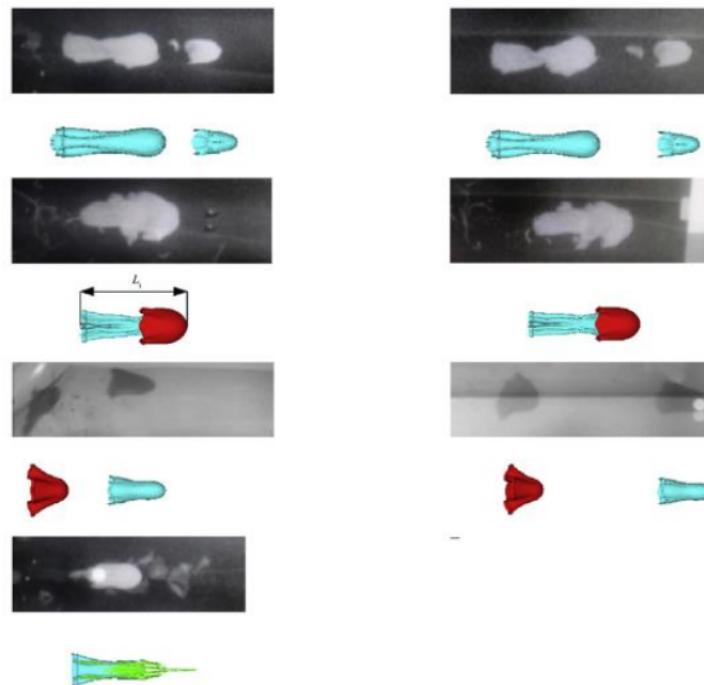


Figure 2 - Tandem EFP Formation, Simulation, and Imagery [7]

Theoretically, formation and separation occur in four stages, the impact phase, propulsion phase, slide phase and free-flight phase [7]. The axial and radial impacts are most likely to have an influence on the formation of the EFPs before they separate [7]. This research will seek to support these claims along with the bigger picture whilst capturing better imagery of the EFPs using flash x-ray to analyse the in-flight stability and formation. Figure 2 shows that the in-flight stability looks to be irregular. Comparisons will be made between the conventional and multi-layer liners. Should there be unanswered questions arising from this research, more work will be required to investigate these.

3. Aims & Objectives

Aims:

- To investigate the relationship between layering charge liners and the ability to form a coherent EFP.
- To investigate the relationship between having layered charge liners and the damage ability of the resulting EFP (penetration depth and crater size).

Objectives:

- To obtain flash x-ray images of the resulting EFP's produced from both conventional and multi-layer EFP liners,
- To evaluate the depth of penetration that can be achieved by multi-layer EFP liners into a known target when compared to conventional EFP liners,
- To evaluate the crater diameter created from impact into a known target by multi-layer EFP liners when compared to conventional EFP liners,
- To critically analyse the data sets to contrast and compare the efficiency of conventional and multi-layer EFP liners and to quantify the improvement in performance of multi-layer EFP liners (if any).

4. Experimental Design

A comparative approach will be employed for this research.

4.1. Outline of Experimental Procedure

- A steel target of size TBD will be positioned in line with the EFP warhead location,
- The empty charge cases (30mm calibre), complete with EFP liners will be weighed and this noted,
- Charge cases will be hand stemmed with PE4, the top sealed, labelled with liner material type and number,
- Stemmed charges will be weighed providing an explosive charge weight²,
- These stemmed charges will be radiographed³.
- Three initial firings will be conducted as a baseline using conventional single layer Cu EFP liners over a standoff TBC CD
- Three further firings will be conducted on warheads using double layer copper liners⁴.
- Three further firings will be conducted on warheads constructed of two liners of dissimilar materials⁵,
- 3 final firings will be completed with liner materials reversed⁶.

4.1.1. Independent Variables

- EFP liner construction

4.1.2. Dependent Variables

- Depth of Penetration
- Crater size

4.1.3. Control Variables

- Explosive Type (PE4)
- Mass of explosive
- Volume of Explosive
- Standoff
- Target Material
- Charge Diameter
- Charge Length
- Distance between liner layers
- Means of initiation
- Firing Circuit
- Detonator position and orientation

4.2. Data Collection

- Pulsed x-ray⁷

² Labelled on charge.

³ Using XR200 Pulsed X-ray

⁴ No other changes to be made.

⁵ Materials TBC

⁶ E.g., Liner 1 becomes liner 2. Before each firing, the target plate will be adjusted to present an undamaged surface.

⁷ To identify any voids in the main filling

- Flash x-ray⁸
- High Speed Footage⁹
- Crater diameter
- Depth of penetration
- Any recoverable fragments

4.3. Data Evaluation

- High Speed Video will be used to obtain EFP velocity¹⁰.
- The depth of penetration will be analysed and averaged out for each series of EFPs^{11, 12}

4.4. Risks & Limitations

4.4.1. Risks

- Health and Safety – There is the potential for significant physical harm to the investigator as the risks of handling explosives and explosive devices occur along with the use of x-ray.¹³
- Data loss – Data may be lost through targeted attack or during data transfer.¹⁴
- Human error leading to data loss¹⁵

4.4.2. Limitations

- Hand stemming PE4 charges¹⁶.
- Limitation on liner materials to be used¹⁷.

4.5. Ethical Issues

This research is ethically low risk¹⁸.

⁸ This will be used to provide a detailed image of the EFP formation to see if it is coherent and to identify any separation within the EFP. High Speed Video Cameras could be used, however, the flash from the detonation and the detonation products may mask this.

⁹ EFP Velocity

¹⁰ This will be averaged over three measurements for all EFP's and be compared to the conventional EFP with the results being presented as a percentage.

¹¹ This will be presented as a percentage compared to the conventional EFP.

¹² Should further effects be seen, deviations from this plan may be necessary.

¹³ All tasks will be operated in accordance with the COTEC range orders and procedures along with there being a 1-man risk when handling explosives. All personnel will be certified as competent, and all XO's will be in overall control of the x-ray equipment in accordance with the ionising radiation local rules and will be authorised as competent to use the relevant pieces of equipment through the RPS.

¹⁴ Data will be backed up to the cloud, an external hard drive and stored solely on Cranfield University IT as well as Company Network Drives with restricted access. At no point will UWTSD IT be used to store or analyse data.

¹⁵ All personnel will be adequately trained in the operation of all instrumentation. Immediately before the firings take place, all instrumentation status' will be checked to ensure it is ready to capture.

¹⁶ will always give a less homogeneous explosive filling than melt-cast, however, due to limitations on the capabilities of the test site, a melt-cast explosive filling isn't practicable.

¹⁷ Where this is identified, an alternative material will be used where reasonably practicable.

¹⁸ No live subjects will be used human or otherwise, and no personal or sensitive data will be collected or processed.

5. Resources & Planning

5.1. Resources Required

5.1.1. Physical Resources

- 12 no. Charge Cases¹⁹
- PE4²⁰
- 21 no. EFP liners²¹
- 4 no. steel targets²²

5.1.2. Human Resources

- XO (5 days)
- TCO (5 days)
- Senior Instrumentation Technician (5 days)
- Range Support (5 days)

5.1.3. Other Resources

- Range hire (5 days)
- X-ray equipment (5 days)
- High Speed Camera (5 days)
- Velocity Foils (24 no.)

A Gantt chart is provided in **Error! Reference source not found.** in Annex A

¹⁹ 3 no. single liner Cu, 3 no. double liner Cu, 3 no. double liner material TBC, 3 no. double liner material TBC in opposite order

²⁰ 1kg Total NEQ

²¹ 15 no. Cu, 6 no. TBC

²² size TBC

6. References

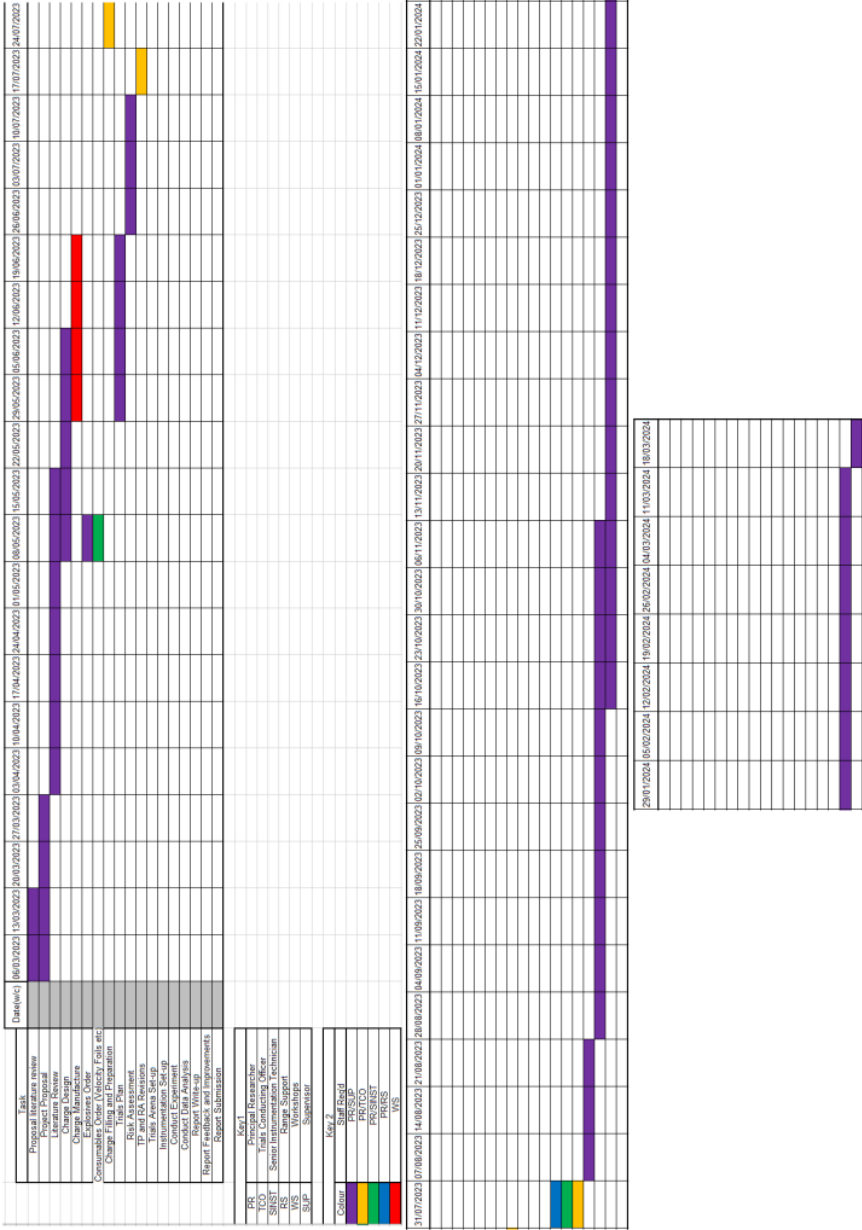
- [1] W.-j. Dong, X.-W. Cheng, S.-K. Li, Q.-H. Zou and W.-Q. Guo, "Penetration Performance of W/Cu double-layer shaped charge liners," *Rare Metals*, vol. 35, no. 1, pp. 184 - 191, 2016.
- [2] H. Wang, H. Guo, B. Geng, Q. Yu and Y. Zheng, "Application of PTFE/Al Reactive Materials for Double-Layered liner Shaped Charge," *Materials*, vol. 12, no. 17, 2019.
- [3] F. Zhang, C. Zhao, W. Feng, C. Ji, S. Lin and X. Wang, "Numerical simulation study on collinear EFP from warhead with double layer liners penetrating into target," *Vibroengineering PROCEDIA*, vol. 39, no. 1, pp. 133 - 138, 2021.
- [4] H. Zhang, Y.-f. Zheng, Q.-b. Yu, C. Ge, C.-h. Su and H.-f. Wang, "Penetration and internal blast behaviour of reactive liner enhanced shaped charge against concrete space," *Defence Technology*, vol. 18, no. 6, pp. 952 - 962, 2022.
- [5] S. Jang, K. Yoo, H. Lim, H.-J. Choi, J. Park and K. Lee, "Experimental and Numerical study on jet properties and penetration of double-layered shaped charge," *Journal of Mechanical Science and Technology*, vol. 34, no. 1, 202.
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- [7] H.-b. Ma, Y.-f. Zheng, H.-f. Wang, C. Ge and C.-h. Su, "Formation and impact-induced separation of tandem EFPs," *Defence Technology*, vol. 16, no. 1, pp. 668-677, 2020.

7. Bibliography

- [1] W.-j. Dong, X.-W. Cheng, S.-K. Li, Q.-H. Zou and W.-Q. Guo, "Penetration Performance of W/Cu double-layer shaped charge liners," *Rare Metals*, vol. 35, no. 1, pp. 184 - 191, 2016.
- [2] H. Wang, H. Guo, B. Geng, Q. Yu and Y. Zheng, "Application of PTFE/Al Reactive Materials for Double-Layered inner Shaped Charge," *Materials*, vol. 12, no. 17, 2019.
- [3] F. Zhang, C. Zhao, W. Feng, C. Ji, S. Lin and X. Wang, "Numerical simulation study on collinear EFP from warhead with double layer liners penetrating into target," *Vibroengineering PROCEDIA*, vol. 39, no. 1, pp. 133 - 138, 2021.
- [4] H. Zhang, Y.-f. Zheng, Q.-b. Yu, C. Ge, C.-h. Su and H.-f. Wang, "Penetration and internal blast behaviour of reactive liner enhanced shaped charge against concrete space," *Defence Technology*, vol. 18, no. 6, pp. 952 - 962, 2022.
- [5] S. Jang, K. Yoo, H. Lim, H.-J. Choi, J. Park and K. Lee, "Experimental and Numerical study on jet properties and penetration of double-layered shaped charge," *Journal of Mechanical Science and Technology*, vol. 34, no. 1, 202.
- [6] D. Dawe, "Behind Armour Effects of EFPs," Cranfield University, Shrivenham, 2008.
- [7] H.-b. Ma, Y.-f. Zheng, H.-f. Wang, C. Ge and C.-h. Su, "Formation and impact-induced separation of tandem EFPs," *Defence Technology*, vol. 16, no. 1, pp. 668-677, 2020.
- [8] J. Yin, J. Chen, Y. Han, C. Dou and J. Yi, "Numerical simulation on forming of triple-layer tandem EFP," in *30th International Symposium on Ballistics*, Long Beach, CA, 2017.
- [9] S. Lin, C. Zhao, F. Zhang, C. Ji, L. Zheng and M. Zhong, "Effect of material characteristics of explosive on formation of collinear explosively formed projectile from warhead with double layer liners," *Vibroengineering PROCEDIA*, vol. 40, no. 1, pp. 107 - 112, 2022.

Annex A

Table 1 - Gantt Chart



Annex B

Ethics Approval Form

ETHICS FORM – ~~SWAC~~ STUDENTS ONLY

APPLICATION FOR ETHICAL APPROVAL

~~In order for~~ research to result in benefit and minimise risk of harm, it must be conducted ethically.

The University follows the OECD Frascati manual definition of **research activity**: "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". As such this covers activities undertaken by members of staff, postgraduate research students, and both taught postgraduate and undergraduate students working on dissertations/projects.

The individual undertaking the research activity is known as the "principal researcher".

This form must be completed and approved prior to undertaking any research activity.

 SECTION A: About You (Principal Researcher)

1	Full Name:	Samuel Martin Page
2	Student Number:	1910580
3	Email address:	1910580@student.uwtsd.ac.uk
4	Programme of Study:	BEng (Hons) Ordnance, Munitions and Explosives (Test and Evaluation)
5	Director of Studies/Supervisor:	Mr Gareth Collett

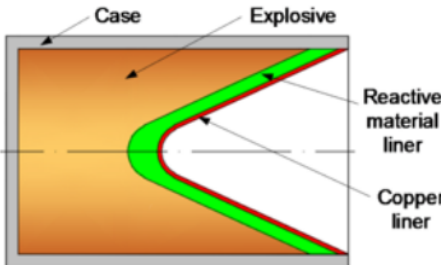
SECTION B: Internal and External Ethical Guidance Materials

	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	<i>Cranfield University Research Ethics Policy</i>	☒
4	<i>Cranfield University Research Integrity Policy</i>	☒
5	<i>Cranfield University Process for Implementation and Monitoring of Research Integrity Policy</i>	☒
6	<i>Cranfield University Management of Research Data Policy</i>	☒

SECTION C: Details of Research Activity

1	Indicative title:	An investigation on the effects of multi-layer charge liners on EFP formation and performance		
2	Proposed start date:	2 nd April 2023	Proposed end date:	22 nd March 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:				

ETHICS FORM – SoAC STUDENTS ONLY

	• Purpose of Research Activity • Proposed Research Question • Aims of Research Activity • Objectives of Research Activity Demonstrate, briefly, how Existing Research 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 Previously, research has been carried out on the use of dual layered charge liners on SCs looking at the enhancement of penetration or for enhancing behind armour effects [1]. An example has been provided in Figure 1. Extensive research has been conducted on SCs, however, there is a limited amount of research that has been conducted on dual liner EFP warheads. EFPs can be used for a wide range of applications so to fill a gap in knowledge, this research will attempt to form an understanding of the effect these multi-layer liners have on EFP formation and performance. It is believed that, similarly to SCs, the penetration ability will be enhanced, however, this research should inform an understanding of this. Limitations to this technology may be identified for further research.  <i>Figure 1 - Diagram of a dual-layer liner for Shaped Charges [2]</i> This work will work to provide COTEC with the ability to conduct more research projects in the future and assist with the commissioning of a new digital x-ray system. <i>(this box should expand as you type)</i>
4	Research Question When multi-layer charge liners are used in conventional EFP warhead configurations, is the formation and penetrative ability of the projectile affected? <i>(this box should expand as you type)</i>
5	Aims of Research Activity • To investigate the relationship between layering charge liners and the ability to form a coherent EFP • To investigate the relationship between having layered charge liners and the damage ability of the resulting EFP (penetration depth and crater size) <i>(this box should expand as you type)</i>
6	Objectives of Research Activity • To gather a comprehensive set of flash x-ray images of the resulting EFP's produced from both conventional and multi-layer EFP liners. • To evaluate the depth of penetration that can be achieved by multi-layer EFP liners into a known target when compared to conventional EFP liners.

ETHICS FORM – ~~SoAC~~ STUDENTS ONLY

	- To evaluate the crater diameter created from impact into a known target by multi-layer EFP liners when compared to conventional EFP liners. - To critically analyse the resulting data sets to contrast and compare the efficiency of conventional and multi-layer EFP liners and to quantify the improvement in performance of multi-layer EFP liners (if any). (this box should expand as you type)
	Proposed data collection methods (maximum 600 words) Provide a brief summary of all the methods that may be used in the research activity to collect data, making it clear what specific techniques may be used. If methods other than those listed in this section are deemed appropriate later, additional ethical approval for those methods will be needed. You do not need to justify the methods <u>here</u>, but should instead describe how you intend to collect the data necessary for you to complete your project.
7	- High Speed Digital Video. When presented orthogonally to the line of EFP flight, all problems of parallax are removed so you can gain, with a relatively high level of accuracy, an EFP velocity. This footage will not include any living subjects and will be used solely for the EFP velocity and formation where appropriate. - Flash x-ray. Flash x-ray images will be captured to show the EFP formation or both the conventional and multi-layer EFP liners. X-ray will only be used when all personnel are undercover and will not be used on any living subjects. All images will be digital and purely stored on encrypted storage, Cranfield University IT and Company Network Drives with restricted access. - Pulsed x-ray. These images will be used to capture an <u>voids</u> within the charges. X-ray will only be used when all personnel are undercover and will not be used on any living subjects. All images will be digital and purely stored on encrypted storage, Cranfield University IT and Company Network Drives with restricted access. - Crater size. This will be collected manually and recorded in mm directly onto a pre-constructed excel spreadsheet stored on encrypted storage, Cranfield University IT and Company Network Drives with restricted access. - Penetration depth. This will be collected manually and recorded in mm directly onto a pre-constructed excel spreadsheet stored on encrypted storage, Cranfield University IT and Company Network Drives with restricted access. All data stored and transferred will be encrypted and password protected with the passwords being held by the <u>principle</u> researcher solely and only provided to those listed in section H20. (this box should expand as you type)

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?	☐	☒

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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.		
	Details of any other primary data collection method:	☐	☒
	(this box should expand as you type)		

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? (this box should expand as you type)
11	Who will the participants be?

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		<i>(this box should expand as you type)</i>
12	How will you identify the participants?	<i>(this box should expand as you type)</i>

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			
<i>(this box should expand as you type)</i>				

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.	
1	Risks to participants 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 <u>participants</u> then enter N/A and go skip to question 3.	
	Risk to participants:	How you will mitigate the risk to participants:

ETHICS FORM – SoAC STUDENTS ONLY

	N/A <i>(this box should expand as you type)</i>	<i>(this box should expand as you type)</i>
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 <u>actually illegal</u> is discovered in the course of a project, it may need to be disclosed to the proper authorities	
	<i>(this box should expand as you type)</i>	
3	Risks to the investigator For example: personal health & safety, physical harm, emotional distress, risk of accusation of harm/impropriety, conflict of interest	
	Risk to the investigator: There is the potential for significant physical harm to the investigator as the risks of handling explosives and explosive devices occur. There is a health risk related to the use of flash x-ray to the investigator. There is the risk of damage to reputation should data be lost during the <u>project</u> <i>(this box should expand as you type)</i>	How you will mitigate the risk to the investigator: A fully qualified TCO will be present at all times to oversee the safety of all Trials aspects. All explosive works shall be carried out in a fully licensed processing facility in line with the Explosive regulations 2014 and all anti-static procedures laid out in the COTEC Range Orders and Procedures will be followed. All provisions relating to Electromagnetic Radiation laid out in the COTEC Range Orders and Procedures will be followed. Only qualified and authorised personnel are to operate the flash x-ray equipment and all safety alarm inter-locks will be enabled as laid out in the COTEC Ionising Radiation Procedure and COTEC Range Orders and Procedures All data will be stored on company proprietary computers and laptops. Data storage will be <u>encrypted</u> and password protected which won't be shared. Data will be stored in three places at all times and regular back-ups will be <u>performed</u> <i>(this box should expand as you type)</i>
4	University/institutional risks For example: adverse publicity, financial loss, data protection	
	Risk to the University: There is the potential for university systems to be hacked due to the nature of the data being gathered. There is the potential for there to be a damage to university reputation should the data be lost or leaked during transfer or storage. <i>(this box should expand as you type)</i>	How you will mitigate the risk to the University: All data will be stored on company proprietary computers and laptops. Data storage will be <u>encrypted</u> and password protected which won't be shared. University systems won't ever be used to store or process any data for this <u>project</u> <i>(this box should expand as you type)</i>

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5	Environmental risks For example: accidental spillage of pollutants, damage to local ecosystems	
	Risk to the environment: Release of environmentally harmful substances is <u>negligible</u> <i>(this box should expand as you type)</i>	How you will mitigate the risk to environment: <i>(this box should expand as you type)</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?
	Skip this <u>section</u> <i>(this box should expand as you type)</i>
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.
	Skip this <u>section</u> <i>(this box should expand as you type)</i>
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.
	Skip this <u>section</u> <i>(this box should expand as you type)</i>

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	<i>"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.</i>	☐	☒
	If YES, provide a description of the data and explain why this data needs to be collected:		
2	N/A <i>(this box should expand as you type)</i>		
	Does it involve special category data (as defined by the GDPR)?	YES	NO
3	<i>"Special category data" means sensitive personal data consisting of information as to the data subjects' –</i>	☐	☒

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	(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	N/A (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 Manual Files will be scanned and stored on a password protected memory stick immediately after trial completion. All raw data will be stored on a business Network Drive, that is password protected and with restricted access. All USB sticks and Hard Disk Drives will be <u>encrypted</u> and password protected with the passwords being held by the principal researcher solely and only provided to those listed in Section H20. All data will be backed up regularly to company cloud storage which is password protected and the password will be held by the principal researcher solely and only provided to those listed in section H20. All data to be transferred will be through an encrypted transfer and back-ups will be regularly performed both on cloud storage and all USB sticks, portable disk drives etc. Data will be stored and kept until completion of the project and then destroyed. (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?	☐	☒

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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 Manual Files will be scanned and stored on a password protected memory stick immediately after trial completion. All raw data will be stored on a business Network Drive, that is password protected and with restricted access. All data to be transferred will be through an encrypted transfer and back-ups will be regularly performed both on cloud storage and all USB sticks, portable disk drives and Company computers. The passwords will be held by the <u>principle</u> researcher solely and only provided to those listed in Section H20. <i>(this box should expand as you type)</i>		
20	List all who will have access to the data generated by the research activity:		
	Mr Samuel Page (Researcher) Mr Gareth Collett (Supervisor) Mr Trevor Lawrence (Head of Centre/Sponsor) <i>(this box should expand as you type)</i>		
21	List who will have control of, and act as custodian(s) for, data generated by the research activity:		
	Samuel Page (Researcher) <i>(this box should expand as you type)</i>		
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 encrypted and kept in password protected company cloud storage with the password being held solely by the principal researcher and will only be shared with those listed in section H20. All Manual Files will be scanned and stored on a password protected memory stick immediately after trial completion. All raw data will be stored on a business Network Drive, that is password protected and with restricted access. At no point will UWTSD IT services be used for the storage or processing of any research data. Any and all USB sticks and Hard Disk Drives will be encrypted, and password protected with the passwords being held solely by the <u>principle</u> researcher and only provided to those listed in Section H20. At the end of the research project, all external storage will be reformatted to destroy the data and only re-used if <u>absolutely necessary</u>. All data stored on cloud services and company computers/laptops will be stored until project completion and then deleted. <i>(this box should expand as you type)</i>		
22	Confirm that you have read the UWTSD guidance on data management (see https://www.uwt.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 Practice which is published on the website: https://www.uwt.ac.uk/research/research-ethics/

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1	Signature of applicant:		Date: 29/03/2023
2	Director of Studies/Supervisor:	Mr Gareth Collett	Date:
3	Signature:		

FOR INTERNAL USE ONLY:

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

Major Project Proposal - Samuel Page (1910580)

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

67 / 100

Intro / Aim & Objectives (150 words) 246		
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	14
Avoid using acronyms in the title (EFP). Specific gap in previous research has been identified and well defined.		
SMART objectives described however little is said on what is needed in order to be a success. More detail on success criteria and end of project deliverables may have been beneficial.		
Background to the Project / Literature Review (450 words) 373		
Description of how the work to be done in the project relates to the work identified in the literature review.	20	16

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. Familiarity of the topic is demonstrated. Whilst it is good that you have mentioned the four stages in which formation and separation can occur it may be worth pointing out that the axial and radial impacts are related specifically to the propulsion phase. It may also be beneficial to give a small amount of information about the other phases and why they would have less impact on the formation and separation than the propulsion phase. A wide range of academically sound references that are both recent and relevant have been used, very good.		
Project Design (200 words) 287		
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	30	20

Clear plan has been made for the most part, slightly unclear as to the total number of firings (where it says two liners of dissimilar materials, does this mean two different samples with one liner each of differing materials or one sample with two liners in the same projectile of two different materials?). An excessive amount of information (approx. 400 words) has been included as footnotes, while this may be a way of getting around a word limit it is not advised as this information should be included in the body of the text as it is pertinent information.		
Resources / Planning (200 words) 56		
List of any deliverables. Clear diagram showing both timing and resource use. Completed ethics form. Limited and relevant appendices Gantt chart has been included however there is a very tight turnaround estimated for the trial and experiment phases, what happens if something goes wrong or additional/alternative paperwork or health and safety sign off is required? Whilst the gantt charts and ethics forms may be considered stand alone documents, in this context they are required as a part of the proposal and as such "appendix" may be a more suitable term than	15	10

“annex”. Efforts made throughout to list deliverables.		
Document Presentation		
Correct spelling. Grammar and punctuation. Flow of narrative/fluency. Coherence. Word processed. Correct use of referencing with bibliography. Strict word limit for main text – 1000 words. Correct spelling and grammar used throughout. Whilst it is good that a list of abbreviations has been included the flow of reading is interrupted considerably by having to go back and forth between the body of text and this list. The general rule of thumb with using abbreviations is to write the full term the first time that it is used with the abbreviation in brackets and future uses are just the abbreviation. The list would also benefit from being in alphabetical order for ease of use. Typo in reference [5] (year is quoted as “202”). Kept within 10% of the word limit for main text, however this may not have been the case if important information from the footnotes were included in the body of the text.	15	7

TOTAL	100	67
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