

PROJECT TROJAN PROJECT REPORT

Work Group Based Project Report

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Level 5 Work Based Group Project
ACDA5022 | Ordnance, Munition and
Explosives Degree Apprenticeship

ABSTRACT

During a university Work Based Group Project, a group of students undertook a design task to develop a concept design for a weapon system capable of neutralising a hostile communication centre. This report outlines how the team worked together through the project's development, while highlighting the role of the Product Safety Lead (PSL).

The PSL managed the project by implementing a project timeline focusing on the systems engineering toolset and allocated tasks based on the team members skills. Through in-person collaboration and remote communication methods the team ensured timely completion of the tasks. The basis of safety was established by work performed by the PSL, primary on the identification and analysis of hazards within the system.

The concept design of a modular drone system was presented at a Final Design Review in a team presentation that reflected the cohesive approach taken. Post project reflection and presentation feedback identified areas of improvement in remote communication style and presentation delivery style, while crediting the teams understanding of the subject matter and organisational skills.

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1 INTRODUCTION

The ability to work collaboratively in a team is a highly valued skill among employers [1] as it promotes communication and relationship building [2]. Research conducted by the Institute for Corporate Productivity indicated that teams which collaborate efficiently may achieve productivity levels up to five times higher than less collaborative teams [2]. In an academic environment, collaboration can benefit students' development. Some examples are provided in Table 1-1, along with some potential drawbacks which students may need to overcome [1, 2, 3, 4].

Table 1-1 - Benefits and Drawbacks of Group Projects for Students

BENEFITS	
<i>Increased Information</i>	Due to the variety of backgrounds and experiences, groups have a greater pool of resources and information available.
<i>Increased Problem-Solving Ability</i>	The collaborative environment promotes brainstorming and encourages the challenging of others' ideas which can help minimise trial and error solutions.
<i>Improved Learning Ability</i>	Students learn better when they are actively involved in the process as it supports the application of knowledge.
<i>Provides Practical Experience</i>	Group projects allow students to learn teamwork, leadership and conflict management skills which will enable them to improve performance in the workplace.
DRAWBACKS	
<i>Pressure to Conform</i>	In group projects individuals may agree to a bad solution to avoid conflict.
<i>Individuals Dominating Discussion</i>	An individual may dominate the discussion, not allowing other team members to express their opinion, thus alienating them from the decision making.
<i>Lack of Participation from Members</i>	Some team members may rely too heavily on others to do the tasks and will not adequately contribute to the group.
<i>Group Conflict</i>	Team members may conflict due to several reasons including poor communication skills, differing in opinions, viewpoints or personalities, biases and variation of learning or processing styles.

A group of students collaborated to produce a weapon system in response to a Mission Brief provided as part of a university Work Based Group Project. The students were required to form a design team and develop a design concept for a weapon system capable of neutralising a hostile communications centre whilst causing minimal collateral damage to the rest of the building structure or potential occupants. Systems Thinking Design [5] outlines the system engineering toolset used to aid the decision making, whereas, this report explores the approach the team took to effectively work together, with a focus on the Product Safety Lead’s role.

1.1 THE DESIGN TEAM

The design team consisted of six students, each taking on a key role to aid in the systems development. The roles and the associated student are listed in Table 1-2, with the Product Safety Lead also taking on the role of Project Manager.

Table 1-2 - Design Team Roles

ROLE	STUDENT
RESEARCH AND DEVELOPMENT LEAD	Leo Smith
PRODUCT SAFETY LEAD	Emalie Halifax
TESTING AND EVALUATION LEAD	Alex Lamdin
MANUFACTURING LEAD	Libbie Bush
PROCESS SAFETY LEAD	John Hamilton
BREAKDOWN AND DISPOSAL LEAD	Samual Hawkins

2 DESIGN PROJECT MANAGEMENT

Effective project management within a team dynamic is essential to completing a project on time and to the required specification [6]. It ensures that teams stay aligned with the intended objectives, while supporting the delivery of a quality product. By providing a clear realistic project plan, team members can be empowered to work within limits and not chase irrational or unrealistic desires.

2.1 HOW THE PROJECT WAS MANAGED

The Product Safety Lead (PSL) managed Project Trojan, with the Research and Development (R&D) Lead initially developing an outline of the required processes to deliver the mission specifications. The outline was used by the PSL to produce an initial project timeline. The project

was split into the eight phases in Table 2-1, with each phase projected to take a week to complete and an overall project timescale of eight weeks. These phases focused on the systems engineering tools that the students had previously learnt. As the project progressed, more tools were introduced to the team and the project timeline was updated to reflect the new tasks.

Table 2-1 - Project Trojan Design Phases

PHASE ONE	System Requirements
PHASE TWO	Generic Functionality
PHASE THREE	Concept Development
PHASE FOUR	Sub-System Functionality
PHASE FIVE	Sub-System Concept Development
PHASE SIX	Manufacturing Functionality
PHASE SEVEN	Manufacturing Critical Process
PHASE EIGHT	Final Design Review (Presentation)

Figure 2-1 – Figure 2-3, shows the project timeline for phases two, three and six, and provides an example of how the tasks were assigned to each team member. This timeline was accessible to all team members in the Project's Design Book [7] and allowed team members to update their progress.

Any tasks which benefited from a multidisciplinary approach were scheduled for time where all or a majority of the design team were available. To ensure completion by the intended deadlines, some tasks were allocated to a subdivision of the team or individuals based on their skillset. This ensured each team member had the opportunity to contribute to the development of the design and share their ideas.

Phase Two: Determine Functionality						
Deadline:	16/02/2025	End Week 1				
Task			Due Date	Assigned To	Progress	Completion Date
☐	Determine Generic Functionality			Group		14 February 2025
	☐	Functional Flow Diagram				
	☐	Core Fuctionality				
	☐	Emergent Behaviour				
☐	QFD 1		17 February 2025	Group		17 February 2025
	☐	Functional Importance				
	☐	Function Tests				
☐	Function Failure Mode Effect Analysis		18 February 2025		Change in Generic Functionality at Development of Concept Solution has made some of these redundant - Scope to redo? Limited on Time	
	☐	Additional Functions/Requirements				
	☐	Infiltrate/Penetrates target		Emalie		
	☐	Deliver terminal effect		John		
	☐	Move to target		Alex		
	☐	Generate motive force		Leo		
	☐	Acquire target		Sam		
	☐	Guide to target		Libbie		
☐	Repeat QFD 1 (If needed)		Not Required	N/A		
☐	Functional N2 Analysis		18 February 2025	Emalie		
	☐	Functional Importance				
☐	Functional Metrics Analysis		18 February 2025	Alex	Done - To be uploaded	
	☐	Testing Criteria for important Function				

Figure 2-1 - Project Trojan Design Phase Two Timeline

Phase Three: Concept Development							
Deadline:	23/02/2025	End Week 2					
Task				Due Date	Assigned To	Progress	Completion Date
☐	Function Means Analysis			19 February 2025	Group		18 February 2025
	☐	Identify Three Solutions					
☐	Compare Designs			19 February 2025			18 February 2025
	☐	Pugh Diagram (Scenario 1)					
	☐	Pugh Diagram (Scenario 2)					
	☐	Pugh Diagram (Scenario 3)					
☐	Design Review With Customer			Thurs, 20th Feb		Pre Review (18/2/25)	20 February 2025
	☐	Solution to Take Forward				Design 2 Taken forward	
☐	Determine Solution Based Generic Functionality				Group		18 February 2025
	☐	Functional Flow Diagram					
	☐	Core Fuctionality					
	☐	Emergent Behaviour					
☐	Solution QFD 1			17 February 2025	Group		18 February 2025
	☐	Functional Importance					
	☐	Function Tests					
☐	Function Means Analysis			19 February 2025	Group		19 February 2025
	☐	Identify Solutions to new Functionality (1 Design Needed)					
☐	Compare Designs			19 February 2025	Group		19 February 2025
	☐	Pugh Diagram (Scenario 1)					
	☐	Pugh Diagram (Scenario 2)					
	☐	Pugh Diagram (Scenario 3)					
☐	QFD 2			19 February 2025	Group		19 February 2025
	☐	Feature Importance					
☐	Functional Metrics Analysis			19 February 2025	Alex		
	☐	Testing Criteria for important element					
☐	Solution N2 Analysis			19 February 2025	Group		19 February 2025
	☐	Feature Importance					
☐	System P-Diagram (Optional)			21 February 2025	N/A	Might be beneficial to just do at sub-system/component level	
	☐	Noise Factors					
	☐	Control Factors					
☐	System What/Why Table (Optional)			21 February 2025	N/A	Might be beneficial to just do at sub-system/component level	
	☐	Control Importance					
	☐	Noise Importance					
☐	Design Review Actions			21 February 2025			
	☐	Fix Highlighted Requirements			Leo		
	☐	Split requirements into pariwise and filtered down			Leo		
	☐	Functional Flow Diagrams (x2) need Desirable outputs added			Emalie		21 February 2025

Figure 2-2 - Project Trojan Design Phase Three Timeline

Phase Six: Manufacturing Generic Functionality						
Deadline:	16/03/2025	End Week 5	TBC			
Task			Due Date	Assigned To	Progress	Completion Date
☐	Identify Manufacturing Stakeholders		20 February 2025	Group		20 February 2025
	☐ Boundary Map					
	☐ Stakeholder Influence Map					
☐	Gather Manufacturing Requirements		20 February 2025	Group		20 February 2025
	☐ Interview (Libbie)					
	☐ Use Case					
	☐ Gemba Visit					
	☐ Affinity Diagram					
☐	Critical Component P-Diagram		14 March 2025	Emalie John		13 March 2025
	☐ Noise Factors					
	☐ Control Factors					
☐	Critical Component What/Why Table		14 March 2025	Emalie John	Important Noise: Deterioration of Manufacturing Equipment then RDX Density Important Control: Material Quality then Pallet Geometry	13 March 2025
	☐ Control Importance					
	☐ Noise Importance					
☐	Determine Manufacturing Generic Functionality		14 March 2025	Libbie Sam		14 March 2025
	☐ Sequence Flow Diagram					
	☐ Core Functionality					
	☐ Emergent Behaviour					
☐	Manufacturing QFD 1		14 March 2025	Libbie Sam Alex Leo	Need Pairwise Weighting	14 March 2025 (On Call with EH, LB, SH, AL)
	☐ Functional Importance					
	☐ Function Tests					
☐	Process Function Failure Mode Effect Analysis		21 March 2025			
	☐ Additional Functions/Requirements					
	☐ Function 1			Emalie		
	☐ Function 2			John		
	☐ Function 3					
	☐ Function 4					
	☐ Function 5 (TBC)			(Additional Input might be required)		
	☐ Function 6 (TBC)					
☐	Manufacturing Process Function Means Analysis		14 March 2025	Group EH, LB, AL, SH, LS		14 March 2025
	☐ Identify Three Solutions					
☐	Compare Manufacturing Processes		14 March 2025	Group (on Call) EH, LB, AL, SH, LS	Need Pairwise Weighting	14 March 2025
	☐ Pugh Diagram					
☐	QFD 2		14 March 2025	Group (on Call) EH, LB, LS	Need QFD1 Weighting	14 March 2025
	☐ Feature Importance					

Figure 2-3 -Project Trojan Design Phase Six Timeline

2.2 COMMUNICATION WITHIN THE TEAM

The initial and final two weeks of the project was during the team's university blocks and allowed for face-to-face communication, whereas the middle four weeks was during their time away from university and required remote communication methods.

2.2.1 In-Person Communication

The in-person communication consisted of group meetings which allowed for collaborative thinking and brainstorming activities. This was beneficial during the requirements and concept derivation phases where a highly collaborative approach was desirable. During the brainstorming activities, constructive discussion was encouraged both to generate interesting ideas and to introduce concepts other team members may not have been aware of.

While this approach was welcomed by the whole team, there were some challenges regarding the number of meetings and their timings. The team took advantage of the time around lectures to progress with the group tasks. It became clear that the Disposal Lead was not making themselves available on specific days when they should have been, these were days which did not have scheduled lectures, predominantly after the weekend. Rather than allowing this to delay the project, the team decided to utilise the face-to-face time to progress with the work. The Disposal Lead was updated on the project's development and any decisions made in the next meeting they attended.

2.2.2 Remote Communication

During the break from university, the team was unable to meet face-to-face, meaning that communication consisted of an informal group chat on a messaging application and a formal weekly meeting. The weekly meeting was held on Microsoft Teams, the meeting invite is provided in Figure 2-4, with all team members encouraged to attend. Understandably, there were occasions where team members were unable to attend, in these cases the meeting was recorded for decision traceability and to record minutes of the meeting.

These meetings were well attended and still allowed for the collaboration needed for the assigned tasks. Any actions resulting from the meeting were communicated in writing to the team in the group chat, allowing further discussion if required. An example is provided in Figure 2-5.

WBGP Meeting

Chat

Shared

Details

Recap

Meeting Whiteboard

Q&A

Join

Close

RSVP

Copy link

Forward

Show as: Tentative

Category: None

14 March 2025 13:00 - 16:00

View series

Show meeting info

Recording

02:46:43

Transcript

Show join info

The organiser hasn't added any notes yet

Tracking

JH

John Hamilton (2221981)

Organiser

SH

Sam Hawkins (2216506)

Accepted

EH

Emalie Halifax (2222482)

No response

AL

Alexander Lamdin (22176...

Unknown

LS

Leo Smith (2217998)

Unknown

LB

Libbie Bush (2223155)

Unknown

Optional

LS

lsmith6@dstl.gov.uk

Unknown

Figure 2-4 - Project Trojan Re-Occurring Remote Meeting Invite

11

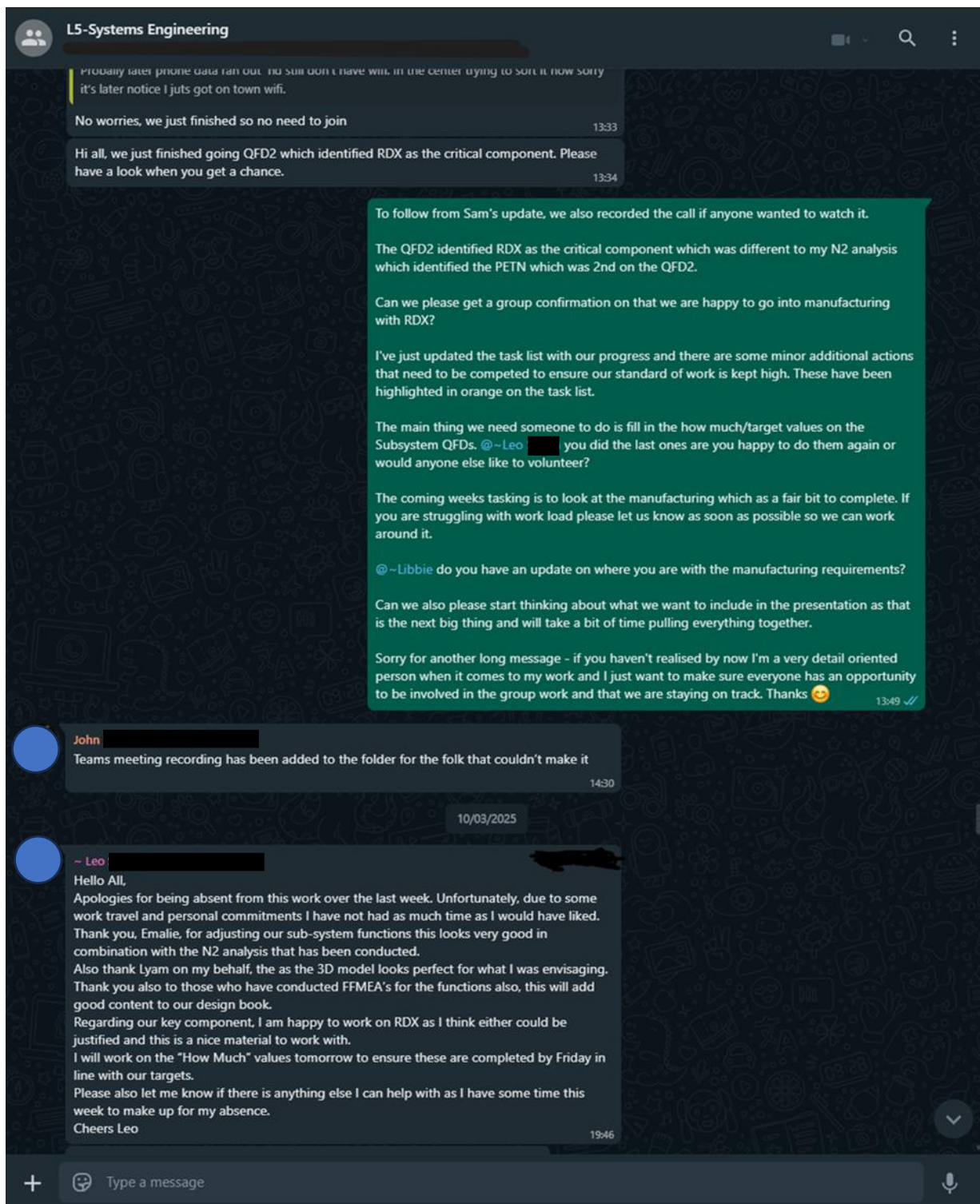


Figure 2-5 - Remote Post Team Meeting Communication

3 THE ROLE OF PRODUCT SAFETY

The project had a number of set deliverables aligned with the five subject areas relating to the design team's roles. To develop the basis of safety, the Safety Roles had to:

- Demonstrate an understanding of the safety requirements of their area.
- Demonstrate the safety legal requirements.
- Identify key hazards associated with their area of operation.
- Perform critical analysis of the key hazards.
- Outline mitigations required for the hazards.

Due to the wide scope of the project and the need for safety at all product lifecycle phases, the Safety Role was split into Product Safety and Process Safety. The Product Safety Lead focused on safety of the system design and worked with the Testing and Evaluation Lead (TEL) to ensure the recommended trials regime satisfied the safety requirements, while providing support to the Process Safety Lead and wider team where necessary.

3.1 SYSTEM SAFETY

3.1.1 Safety Requirements

System safety incorporates the safety functions designed into the overall system. The PSL consulted regulatory documentation, outlined in Table 3-1 [8, 9, 10, 11, 12, 13, 14], to ensure an understanding of the safety requirements. This supported the development of the customer requirements and ensured suitable safety considerations were included.

Table 3-1 - Product Safety Lead Document Review

DOCUMENT	USE
DSA 02.OME - DEFENCE ORDNANCE, MUNITIONS AND EXPLOSIVES (OME) REGULATIONS [8]	Outlined the defence regulatory requirements for explosives and weapon systems.
EXPLOSIVE REGULATIONS 2014 [9]	Outlined the civilian regulatory requirements for explosives.
HSE MANUAL HANDLING OPERATIONS REGULATIONS 1992 [10]	Outlined the manual handling requirements for personnel to ensure the system could be operated by the designated human resource.
DEFENCE STANDARD 00-056 – SAFETY MANAGEMENT REQUIREMENTS FOR DEFENCE SYSTEMS [11]	Outlined the defence requirements for managing safety for defence systems.
AOP-15 – GUIDANCE ON THE ASSESSMENT OF THE SAFETY AND SUITABILITY FOR SERVICE OF NON-NUCLEAR MUNITIONS FOR NATO ARMED FORCES [12]	Outlined the assessment criteria for non-nuclear munitions and provided minimum performance criteria for the system.
DSA 03.OME PART 1: DEFENCE CODE OF PRACTICE (DCOP) 101 – OME DESIGN REQUIREMENTS [13]	Outlined defence regulatory guidance for Ordnance Munitions and Explosives (OME) design requirements.
DSA 03.OME PART 2 – DEFENCE CODE OF PRACTICE (DCOP) AND GUIDANCE NOTES FOR IN-SERVICE AND OPERATIONAL SAFETY MANAGEMENT OF OME [14]	Outlined defence regulatory guidance for managing operation safety for weapon systems.

3.1.2 System Failure Modes and Hazard Analysis

To support the development of the design, the PSL identified and analysed the failure modes using Failure Modes Effect Analysis (FMEA). This was performed at both system and subsystem level, focusing on generic functionality and design. The PSL provided the FMEA for the system function *Penetrate Target* and the subsystem function of *Receive Shockwave*. As described in the project's Systems Thinking Design Report [5], an FMEA allowed the PSL to identify potential hazards and recommend mitigations to be incorporated into the design of the system.

When considering what mitigations to implement, the PSL applied a Hierarchy of Controls as shown in Figure 3-1, with the primary focus on eliminating or reducing hazards. The concept design included four rotary blades as part of the propulsion subsystem, shown in Figure 3-2. A Preliminary Hazard Assessment identified the blades as a potential hazard to both personnel during pre-flight procedures, and a possible cause of inadvertent detonation if damaged in-flight. To mitigate this, the PSL recommended adding blade guards to reduce the likelihood of injury to operators and to prevent the blades during flight. This recommendation was incorporated into the final concept design.

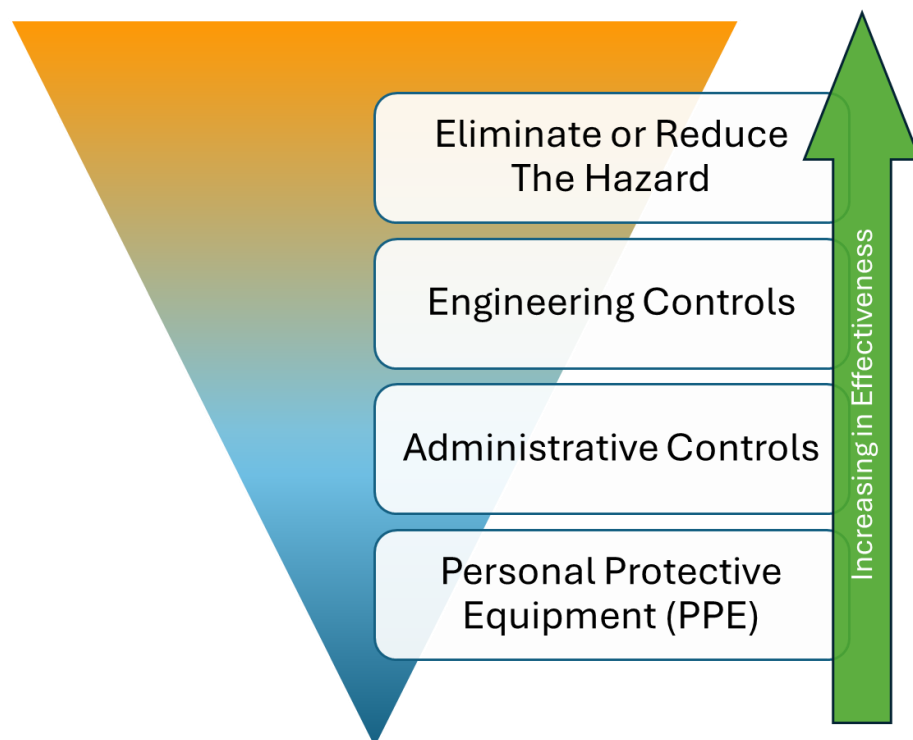


Figure 3-1 - Hierarchy of Controls



Figure 3-2 - Project Trojan Initial Concept Design

3.1.3 System Noise Analysis

The PSL played a key role in identifying and analysing factors, known as noises, which can affect the safety and quality of the critical component of Project Trojan. The importance of noises is described in the Systems Thinking Design Report [5]. Together with the Process Safety Lead, the PSL developed the Parameter Diagram (P-Diagram) for the RDX Pellet by considering any external, unit-to-unit or deterioration noise factors, while considering potential control factors and side effects. These were analysed in the What/Why Table in Figure 3-3. This analysis highlighted the critical noise factors to be managed as well as control factors which needed to be implemented in the manufacturing process and the Process Control Plan.

3.2 TESTING SAFETY

The testing of the design's safety features needed to be incorporated into the testing plan developed by the Testing and Evaluation Lead. The results of these tests would provide assurance that the measures adequately protect the system and people from undue harm.

The PSL worked closely with the TEL to ensure key testing, such as the sensitivity testing of the explosive materials and UN classification testing to ensure the system can be transported safely, were included.

Compone	RDX Pellet	Author	E Halifax, J Hamilton	Date	13/03/2025	Issue	1
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Figure 3-3 - Project Trojan Initiation Subsystem Critical Component What/Why Table

3.3 PROCESS SAFETY SUPPORT

The PSL provided support to the Process Safety Lead by contributing to the Process FMEA (PFMEA) on the function *Weigh Material*, which aided hazard identification for the design of the manufacturing process.

3.4 THE SYSTEM DESIGN

The development of the concept design for Project Trojan was a collaborative approach involving all team members, utilising multiple tools that required the team to work together to find a solution. The PSL provided the basis for the N² Analysis which supported the identification of the critical subsystem and component. This was a new tool introduced during the development of the project which required a period of learning to understand its use. This knowledge was then passed on to the team by the PSL. The importance of N² Analysis and how it contributed to the final decisions are provided in the Systems Thinking Design Report [5].

4 DESIGN PRESENTATION

The concept design, depicted in Figure 4-1 [15], was created in response to the Mission Brief. A modular drone system was designed to neutralise external antennas of a hostile communication system. This was presented at a Final Design Review to both the Customer and representatives from the design team's respective organisations. During this presentation, team members were required to present technical information relating to their areas of expertise to a professional standard. 3D computer models and animations [15] of the concept design were commissioned by the PSL in order to aid the team in presenting their intended solution.

The PSL as the Project Manager, opened the presentation and introduced the team to the attendees. In the Product Safety section of the presentation the PSL covered:

- Why product safety is important.
- The legal requirements for safety.
- How hazards were identified.
- How hazards were eliminated or mitigated.
- The design safety features incorporated at system, subsystem and component level.



Figure 4-1 - Project Trojan Design Concept

To showcase the collaborative approach taken in Project Trojan, the Product Safety Lead developed a template for each team member to use. The full presentation is provided in Annex A - Project Trojan Design Brief Presentation Slides.

4.1 PRESENTATION FEEDBACK

The Group Project Lecturers Dave Holley and Jenni Steen, who represented the Customer for the Mission Brief, provided feedback on the presentation. The focus of the feedback was on:

- The team's approach
- The technical information
- Presenting skills

Table 4-1 presents the feedback provided to the PSL split into two sections: Team Feedback and Personal Feedback.

The team feedback acknowledged their cohesive presentation, which showcased their understanding of the systems engineering toolset used. Feedback for the PSL highlighted their understanding of the subject matter and how safety was embraced at system level and could be traced down to component level.

Areas of improvement were identified such as including a reference slide in the presentation and to ensure consistent delivery pace to allow for easier understanding of technical elements.

Table 4-1 - Product Safety Leady Presentation Feedback

Emalie Halifax	Team 3
Team feedback / Questions	
To the team very well-connected presentation showing that you understand the rationale behind the tool kit. simple slides with a clear layout. Text and images are a good size, easy for audience to view/read. Good contrast between text and background. Reference to other people's sections gives a nice cohesive team unit feeling. Consistent theme used throughout showing collaboration. Good introduction to team members and topics that will be covered. Nice summary wrapping everything up and reminding the audience what has been covered. No references? A slide with references included at the end would have been good.	
Feedback / Comments Dave	
Set out "Menu" for the presentation and introduction Hazard definition well understood. Through life approach taken. Human factors appreciated Safety embraced at system level System safety traced down to component level Specs for test and evaluation handed on	
Feedback / Comments Jenni	
Good volume, reasonably good pace overall but a little fast in places. This could be a little hard for people to follow if they are not familiar with the topic. Good interaction with the audience. Minimal reading from slides, mainly to confirm that the correct legislation is being discussed. Nice, open body language.	

5 POST-PROJECT REFLECTION

Reflection is evaluating what has been done and identifying what could have been done differently. Post-project reflection enables students to develop insights into working collaboratively, with a focus on what to avoid and what to incorporate in future group work [4, 16].

Post-project reflection by the Product Safety Lead identified that the design team performed well in the following areas:

- Delivering a comprehensive design concept which satisfies the mission brief by non-traditional means.
- Delivering to time, with the systems engineering elements being completed by the end of the remote block. This also allowed adequate time to prepare and rehearse the final design review presentation.
- Delivering a cohesive design review presentation to showcase the group effort while highlighting individual's work.

An area in which the team could improve is remote communication, specifically in relation to how they communicated during the remote block. Certain tasks were assigned to be completed before the weekly team call, which in some instances, were not completed on time. The incomplete status of these tasks was not communicated to the rest of the group until the deadline of these tasks was about to elapse. Prior communication of the issues would have enabled other team members to support the completion of the work on schedule.

Based on the presentation feedback including a reference slide in future presentations would highlight where information was obtained from.

5.1 PERSONAL REFLECTION

Reflecting on personal contribution and performance allows students to develop key attributes [17] shown in Table 5-1.

Table 5-1 - Key attributed of Personal Reflection

LEARNING FROM EXPERIENCE	The ability to learn from one's actions.
WORKING EFFECTIVELY	The ability to function more effectively as an individual and collaboratively.
STRENGTHEN COMMITMENT FOR SELF-IMPROVEMENT	The ability to self-criticise and identify areas for development
INCREASED AWARENESS OF SELF-AGENCY AND AUTHORITY	Understanding the importance of being in control of one's actions and understanding the consequences of them.

Through personal reflection, the PSL identified that strong organisational skills were exhibited in their role as project manager. This ensured the team delivered on time, and incorporated float into the schedule for tasks requiring additional resource. An area of self-improvement highlighted was the consideration and accommodation of people's different working styles and having faith in team members to deliver the completion of tasks to be best of their own abilities.

During the presentation, the PSL demonstrated a good understanding of the safety incorporated in the design by outlining the approach taken during the project without referring to notes. Delivering the presentation at a constant rate, keeping the audience engaged while not outpacing their ability to follow, was suggested as a way to improve the quality of the presentation.

5.2 POTENTIAL DESIGN CHANGES

The design team developed a comprehensive concept design in response to the mission brief. The feedback from the design review presentation did not identify any potential design changes. The need to consider the software implementations inherent in the design and the ability to assure the safety of the explosive components used in the system offer another area to be developed. Specifically, the reliance on technological developments within the system and the need to understand any additional risks these present to the sensitive components and their function.

6 CONCLUSION

The design team for Project Trojan successfully developed a concept for a weapon system suitable for neutralising a hostile communication centre, demonstrating collaborative teamwork in an academic environment. The multidisciplinary design team brought a diverse skillset to the project.

Effective project management, led by the Product Safety Lead, ensured a timely completion of the systems engineering tasks using a comprehensive timeline based on the skillset of the team. This was supported by the communication within the team, which incorporated in-person collaboration during the university blocks and remote communication methods, such as weekly calls, during the remote blocks. The team successfully navigated communication challenges during the remote block to ensure adequate completion of tasks.

The role of the Product Safety Lead was essential to establishing the basis of safety for the weapon systems design. This involved demonstrating an understanding of the regulatory safety requirements of the system, along with the identification and analysis of potential hazards. Recommended mitigations were developed by utilising a hierarchy of controls, focusing on the elimination and reduction of hazards.

The design team presented the concept design in a Design Review, which showcased the collaborative approach while highlighting individuals' contributions. Feedback from the presentation acknowledged the team's cohesive approach and strong understanding of the systems engineering methodologies.

Overall, the design team for Project Trojan demonstrated a strong understanding of systems engineering, while fostering a collaborative approach and developing professional skills for future projects.

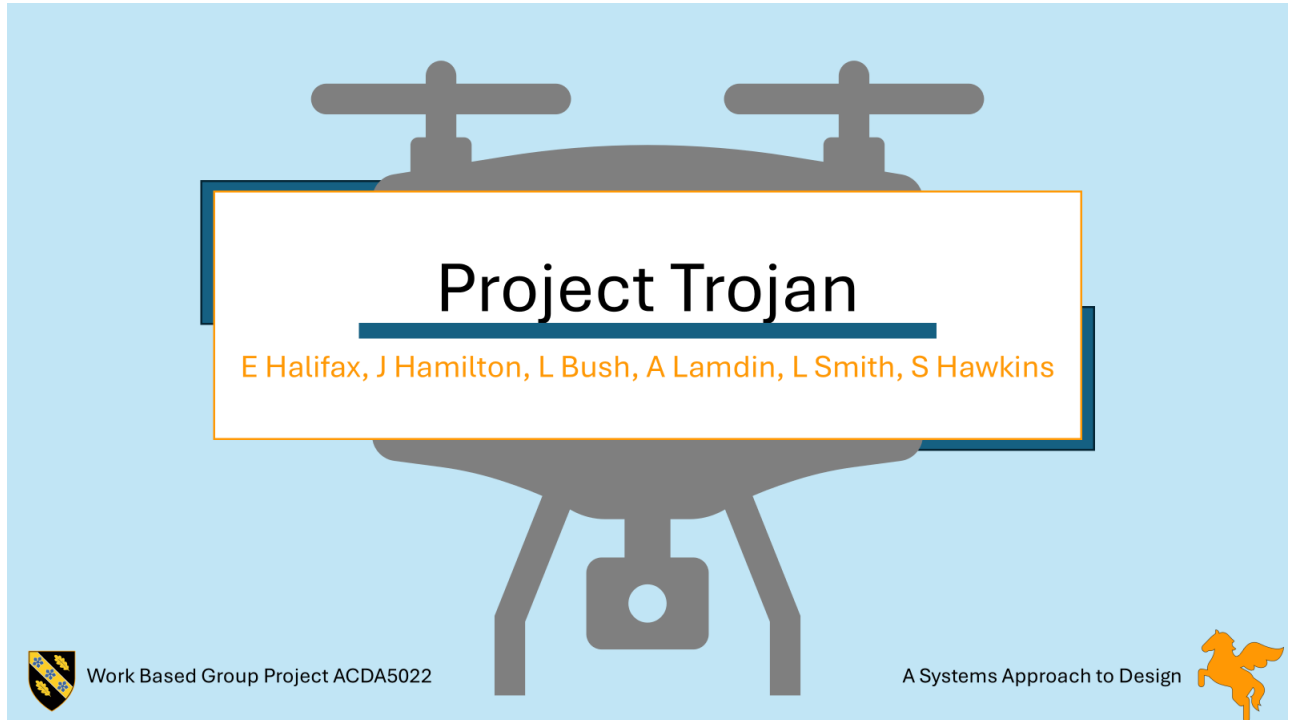
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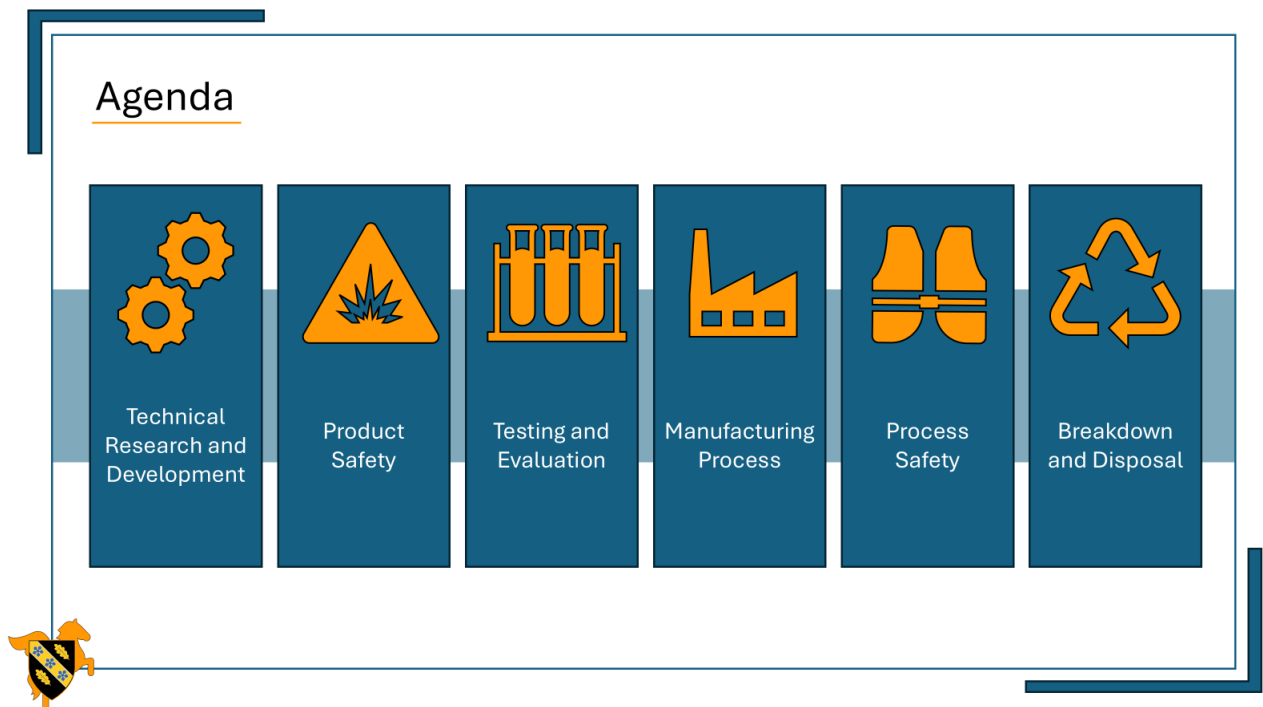
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ANNEX A - PROJECT TROJAN DESIGN BRIEF PRESENTATION

SLIDES



Slide 1 – Project Trojan – Presented by Emalie Halifax



Slide 2 – Agenda – Presented by Emalie Halifax

Meet the Team



EMALIE HALIFAX
Defence Nuclear Organisation
Project Manager
Product Safety



LEO SMITH
Defence Science & Technology
Laboratory
Research and Development



ALEX LAMDIN
Defence Science & Technology
Laboratory
Testing and Evaluation



JOHN HAMILTON
Defence Nuclear Organisation
Process Safety



LIBBIE BUSH
BAE Systems
Manufacturing



SAMUEL HAWKINS
Defence Equipment & Support
Breakdown and Disposal



Slide 3 – Meet the Team - Presented by Emalie Halifax

Technical Research & Development

Presented By: Leo Oliver Smith



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the wider project team



Slide 4 – Technical Research and Development - Presented by Leo Smith

The Mission Objective

“Neutralise a hostile communications centre whilst causing minimal collateral damage to the rest of the building structure or potential occupants.”



Location:
Second Floor of an Office Building



Room Contains:
6 Operatives, 3 Terminals



Access:
3 Windows or 2 Internal Doors



Distance:
100m Away from Personnel

Slide 5 – The Mission Objective - Presented by Leo Smith

System Requirements

Modified KANO Model

Customer Expectation		Expressed	Delight
		High	Low
Customer Expectation	High	- Neutralise Target 100m Range - Cost Equivalent To N-LAW	No Collateral Damage 
	Low		
		Low	High
Customer Satisfaction			

Slide 6 – System Requirements - Presented by Leo Smith

Collecting Additional Requirements

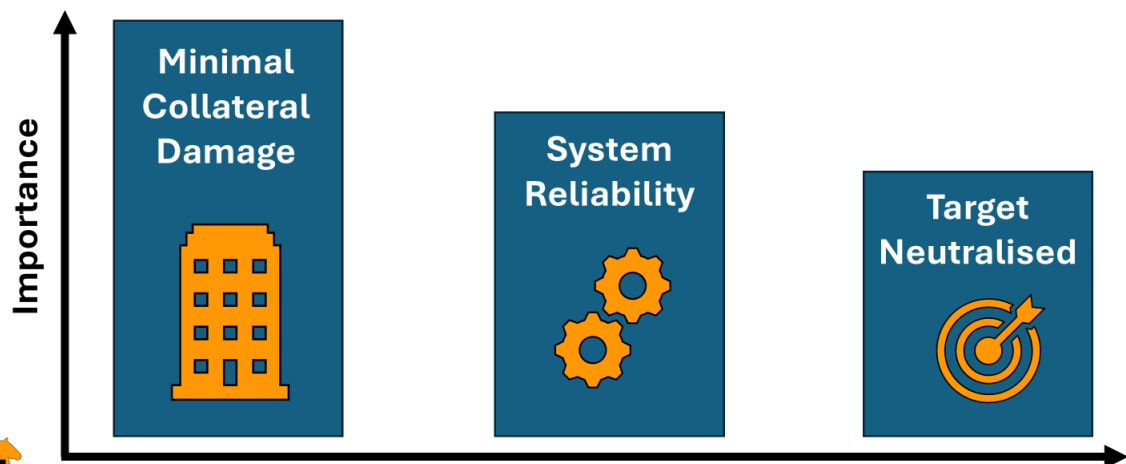
- Consult key stakeholders
- Identify hidden requirements
- Prevent design mistakes



Slide 7 – Collecting Additional Requirements - Presented by Leo Smith

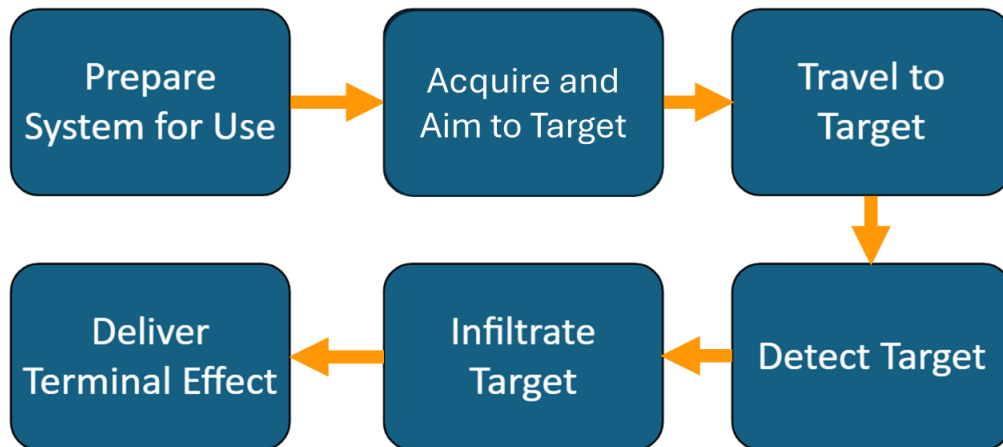
Critical Design Requirements

Results from Pairwise Comparison



Slide 8 – Critical Design Requirements - Presented by Leo Smith

Simplified System Functional Flow



Slide 9 – Simplified System Functional Flow - Presented by Leo Smith

Design Concept

- Low-Cost Single Use Drone
- Advanced Multi Use Control Tablet
- Smart Sensor Suite for Target Detection
- Satellite, Radio or Fibre Optic Control

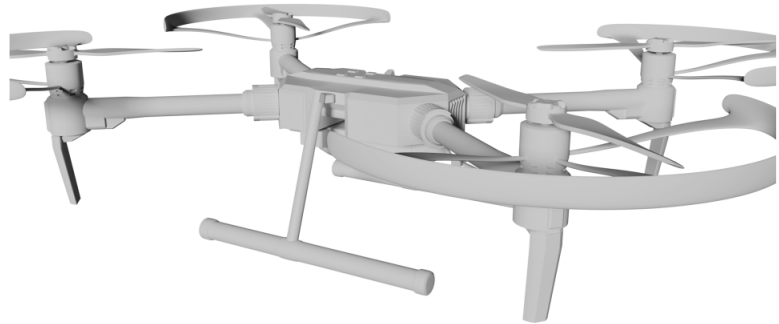


Animations and models provided by L. Hartley

Slide 10 – Concept Design (1) - Presented by Leo Smith

Design Concept

- Modular Payload
- Explosive, Reconnaissance or Electronic Warfare Modules
- Multi Role Capability



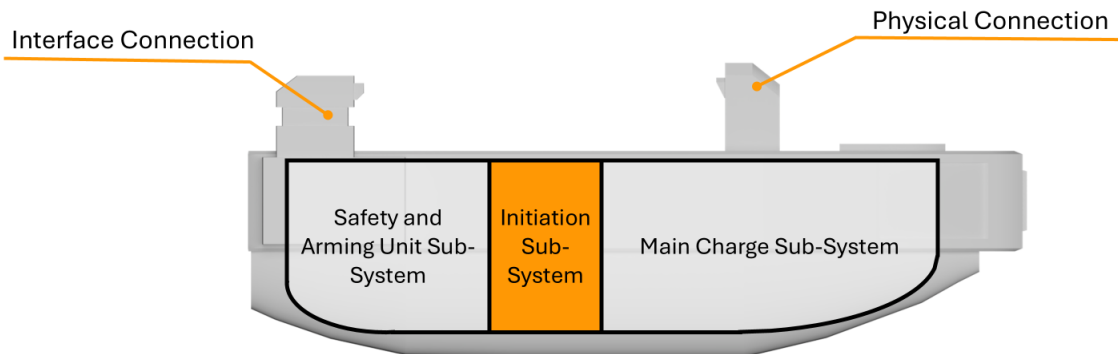
Animations and models provided by L. Hartley

Slide 11 - Concept Design (2) – Presented by Leo Smith



Slide 12 – Concept Animation - Presented by Leo Smith

Warhead Sub-System

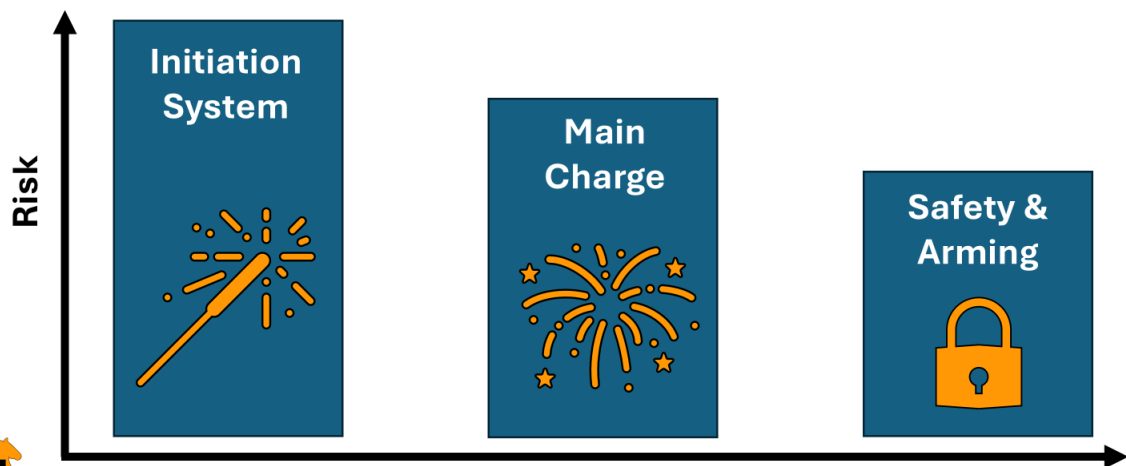


Animations and models provided by L. Hartley

Slide 13 – Warhead Sub-System - Presented by Leo Smith

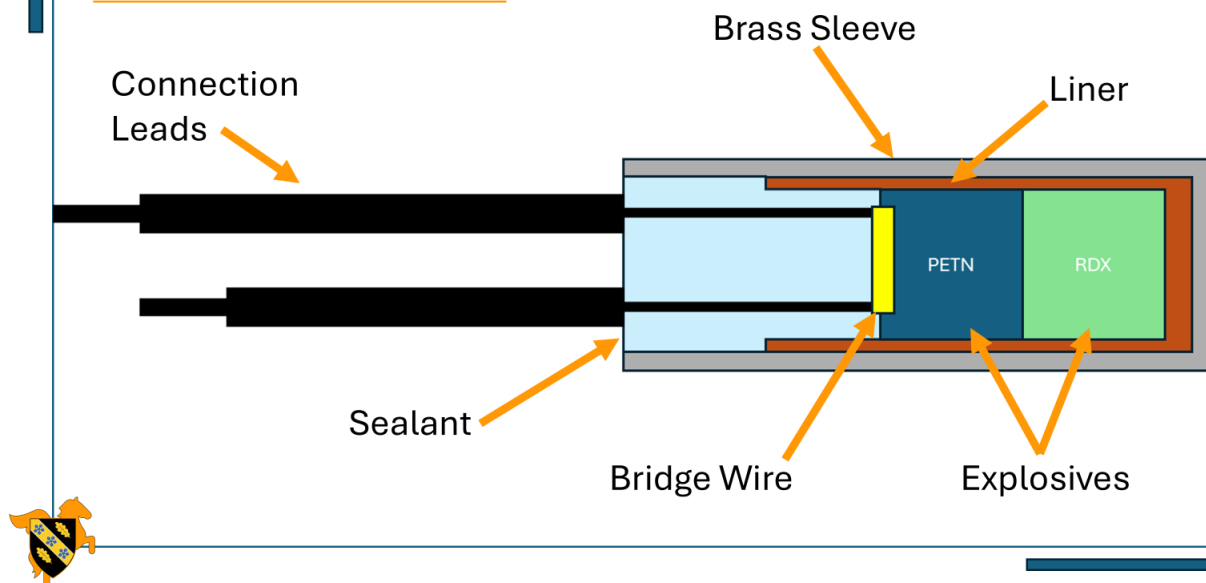
Vulnerable Warhead Sub-Systems

Results from solution QFD2 & Warhead Sub-System N²



Slide 14 – Vulnerable Warhead Sub-Systems - Presented by Leo Smith

Initiation Sub-System

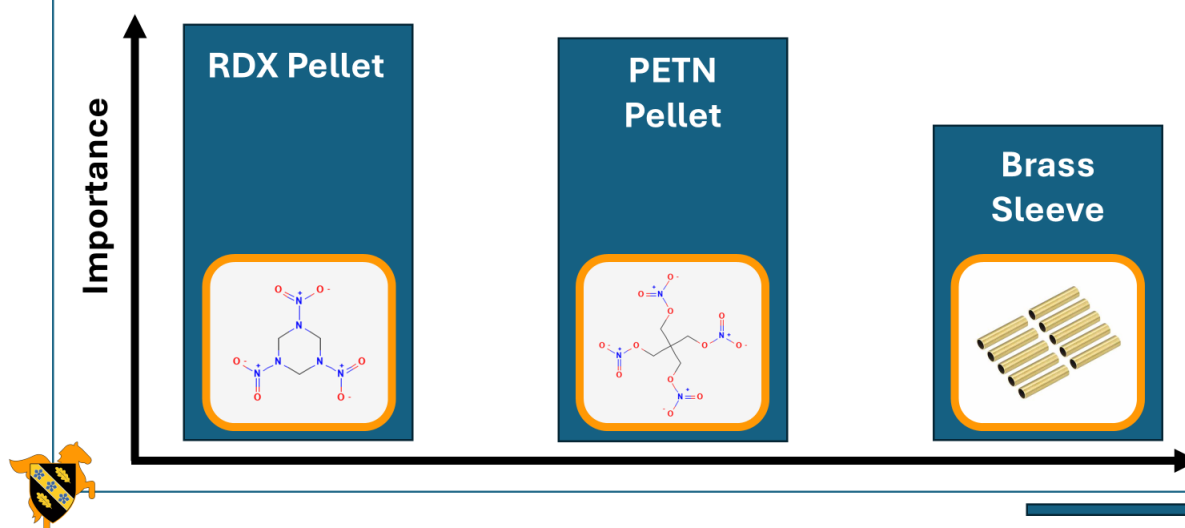


Slide 15 – Initiation Sub-System – Presented by Leo Smith

Critical Initiation

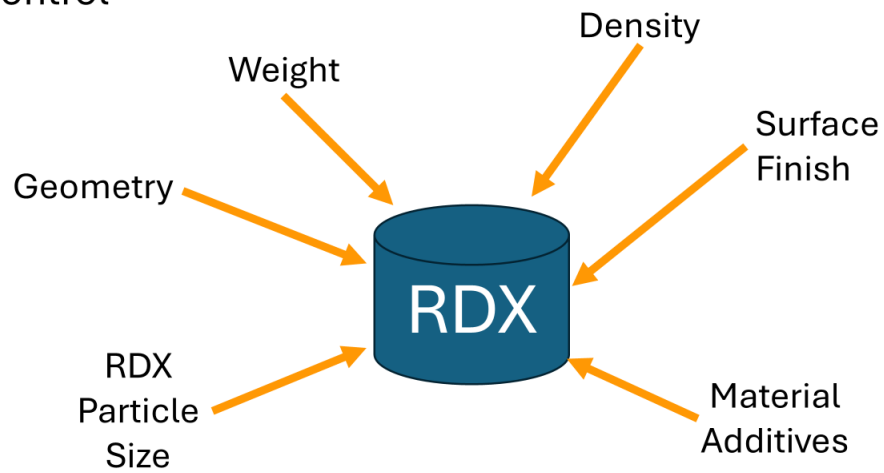
System Components

Results from Initiation Sub-System QFD2 & N² Analysis



Slide 16 – Critical Initiation System Components - Presented by Leo Smith

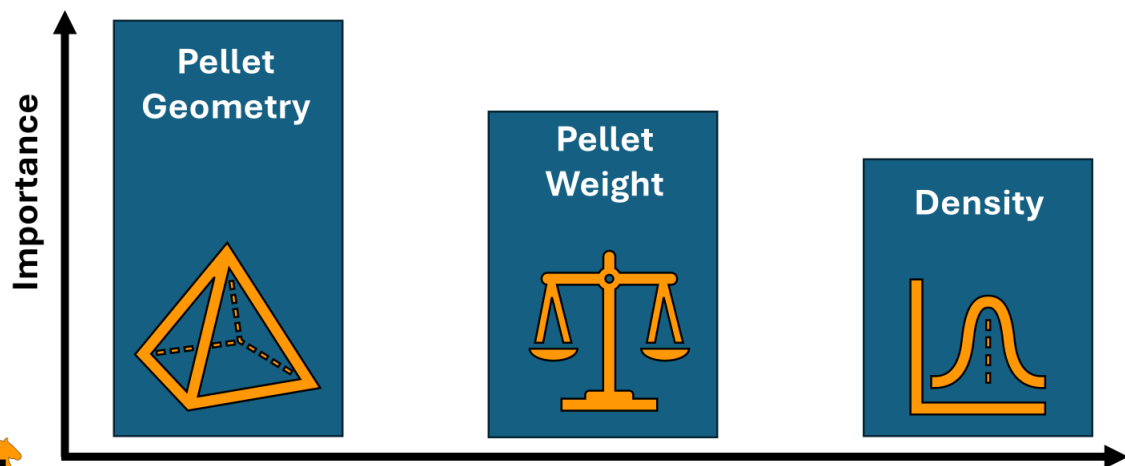
RD_X Pellet Features To Control



Slide 17 – RD_X Pellet Features - Presented by Leo Smith

Critical Manufacturing Controls

Results from RD_X Pellet Parameter -Diagram and What-Why Analysis



Slide 18 – Critical Manufacturing Controls - Presented by Leo Smith

Contributions to the Manufacturing Process

Guidance to manufacturers
on the quality requirements
of the pellet

Requirements

Specifications

Specific target parameters for
the dimensions and weights
of the pellets



Slide 19 – Contributions to the Manufacturing Process - Presented by Leo Smith

Product Safety

Presented By: Emalie Halifax



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Slide 20 – Product Safety - Presented by Emalie Halifax

Why is Product Safety Important?

Why Hazards exist:

- They are unavoidable because hazardous elements must be used in a system
- They are the result of inadequate Design Safety consideration

Hazards are
Created During
Design



Slide 21 – Why is Product Safety Important? - Presented by Emalie Halifax

Explosive Safety

Legislation: Health and Safety at Work Act 1974 (HASAWA 1974)

Regulation: Explosive Regulations 2014 (ER2014)

DSA 02.OME – Defence Ordnance, Munitions and Explosive (OME) Regulations

Prevent, Limit and Protect



Slide 22 – Explosive Safety - Presented by Emalie Halifax

Underpinning Provisions to Explosive Safety



Competent
Persons



Hazard
Awareness



ID Initiation
Source



Controlled
Activity



Hazard
Limitation



Limit People
Exposed



Protect
People



Prevent
Escalation



Safe System
of Work



Remain
Effective



Slide 23 – Underpinning Provisions to Explosive Safety - Presented by Emalie Halifax

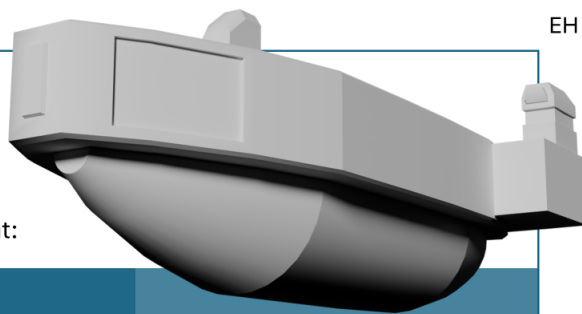
Safety Requirements

The system shall be designed as such so that:

The risk to **health**
and

The risk of an **unsafe event** during
the Manufacture to Target or
Disposal Sequence (MTDS)

Are As Low as Reasonably Practicable (ALARP) and Tolerable.

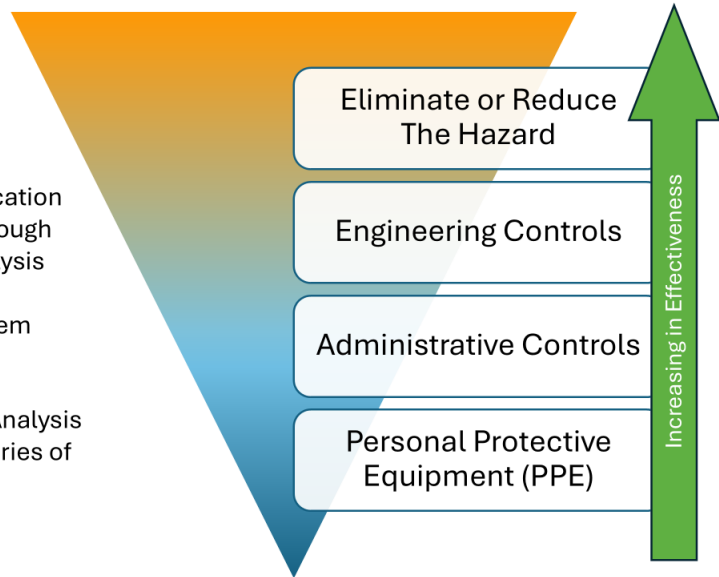


Animations and models provided by L. Hartley

Slide 24 – Safety Requirements - Presented by Emalie Halifax

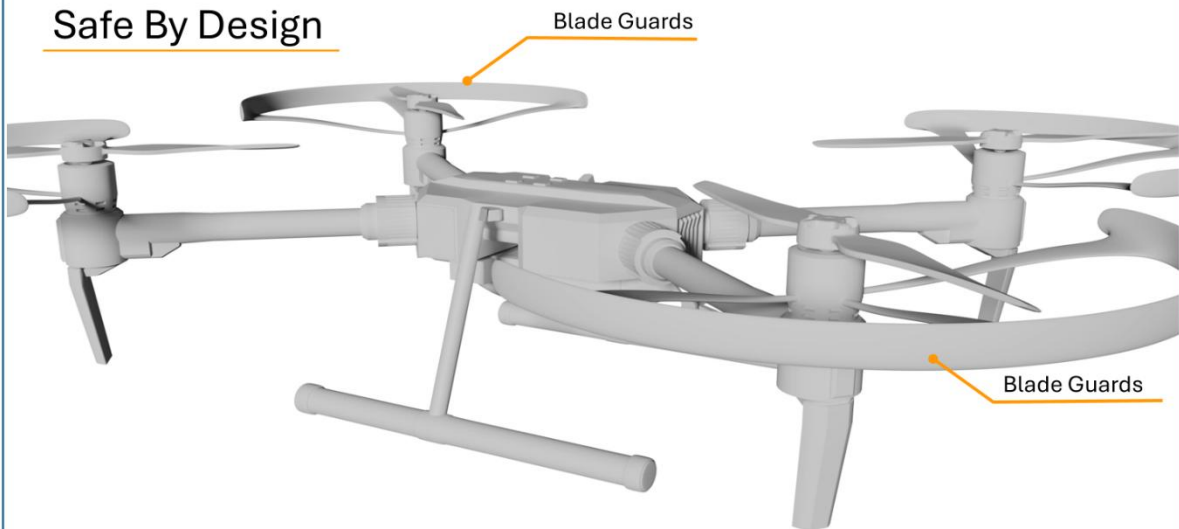
System Safety

- Throughout the design process, hazard identification has been conducted through Failure Effect Mode Analysis on the Design and Functionality of the system
- Throughout the Hazard Analysis process, we applied a series of Hierarchy of Control



Slide 25 – System Safety - Presented by Emalie Halifax

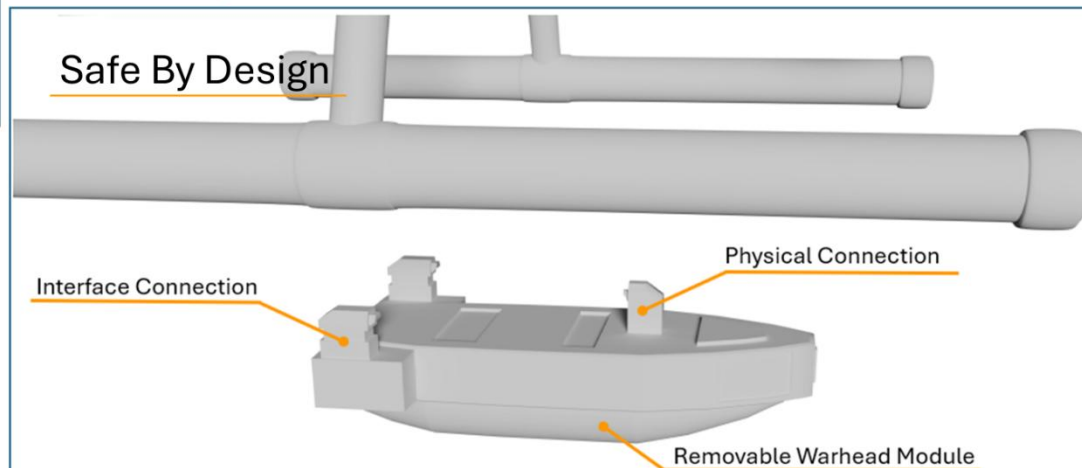
Safe By Design



Animations and models provided by L. Hartley

Slide 26 – Safe by Design (1) - Presented by Emalie Halifax

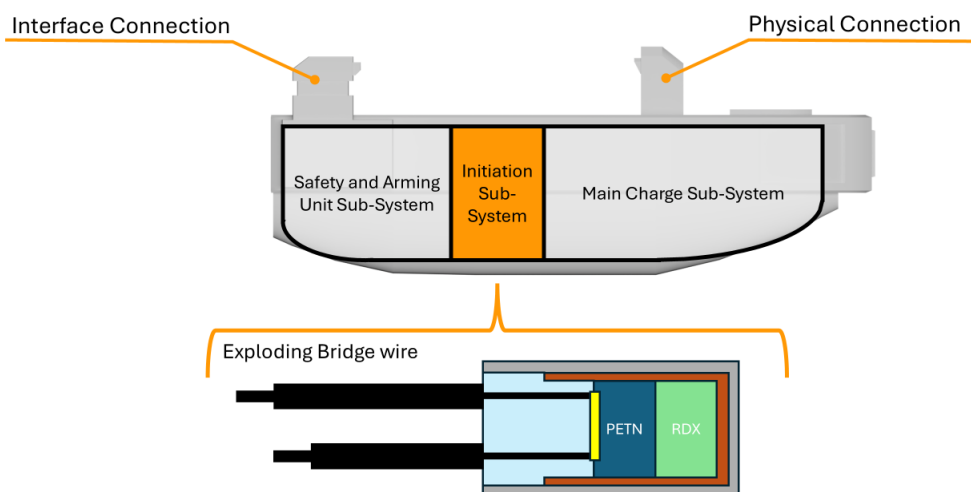
Safe By Design



Animations and models provided by L. Hartley

Slide 27 - Safe by Design (2) - Presented by Emalie Halifax

Safe By Design



Animations and models provided by L. Hartley

Slide 28 – Safe by Design (3) - Presented by Emalie Halifax

Testing & Evaluation

Presented By: Alex Lamdin



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Slide 29- Testing and Evaluation – Presented by Alex Lamdin

Why Test?

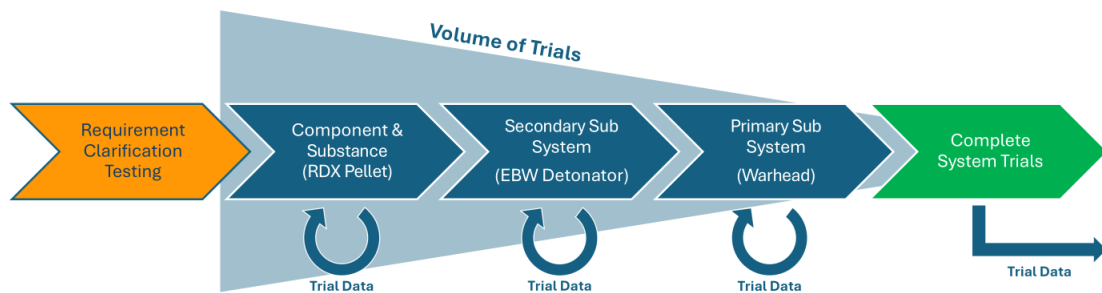


-  Critical Functionality – Will it do what we need it to do?
(Derived from Requirement's)
-  Safety - Is it safe to use? How does it need to be handled and
used to minimise risk to the user?
-  Capability & Limitation Definition – What else can it do? What
are the limits of its performance?
-  Compatibility – What other systems is it compatible with? Does
it conflict with any other systems?



Slide 30 – Why Test? - Presented by Alex Lamdin

Project Trojan Testing Plan



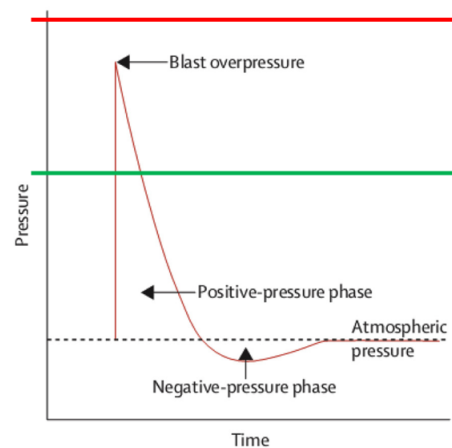
- Conducting Functional Metrics Analysis, advising on QFD target values.
- Advising other project team members on Testing, Trials & Evaluation, as well as on usage practicalities.



Slide 31 – Project Trojan Testing Plan - Presented by Alex Lamdin

Requirement Clarification Testing

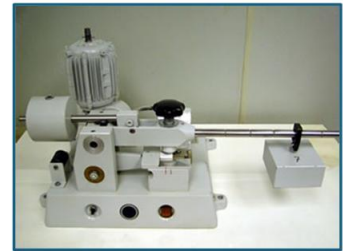
- Target Damage Threshold Testing – How big of a bang do we need to accomplish the mission spec?
- Collateral Damage Threshold Testing – How big of a bang is too much?



Slide 32 – Requirement Clarification Testing – Presented by Alex Lamdin

Component & Substance (RDX Pellet) Testing

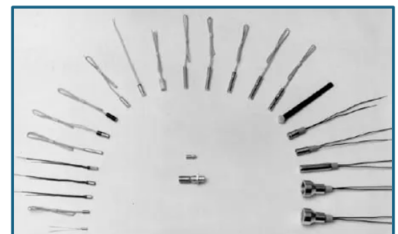
- Substance Testing – Sensitivity (SSHT – EMTAP 1, 2, 3, 4, 5, 6, 7, 33, 43, 44)
- Substance Testing – Performance Characteristics (EMTAP 46 Critical Diameter, EMTAP 47 VoD)
- Completed Pellet energetic output testing – Shockwave Pressure (Quantative or Qualitive)



Slide 33 – Component and Substance Testing - Presented by Alex Lamdin

Secondary Sub-System (EBW Detonator) Trials

- Electrical Initiation Threshold
- Energetic Output
- Time to Function (TTF)
- UN Classification testing (If going to be packaged separately)



Slide 34 – Secondary Sub-System Trials - Presented by Alex Lamdin

Primary Sub-System (Warhead) Trials

- End effect static testing (Lethality & Collateral)
- Environmental testing (Water Ingress, Vibration, etc)
- Main fill sensitivity (SSHT, EMTAP 35, 41, 42 Tube Tests, 36 Frag attack)
- Weight/Size/Portability/UAS Compatibility – Design Feedback into UAS Sub-System



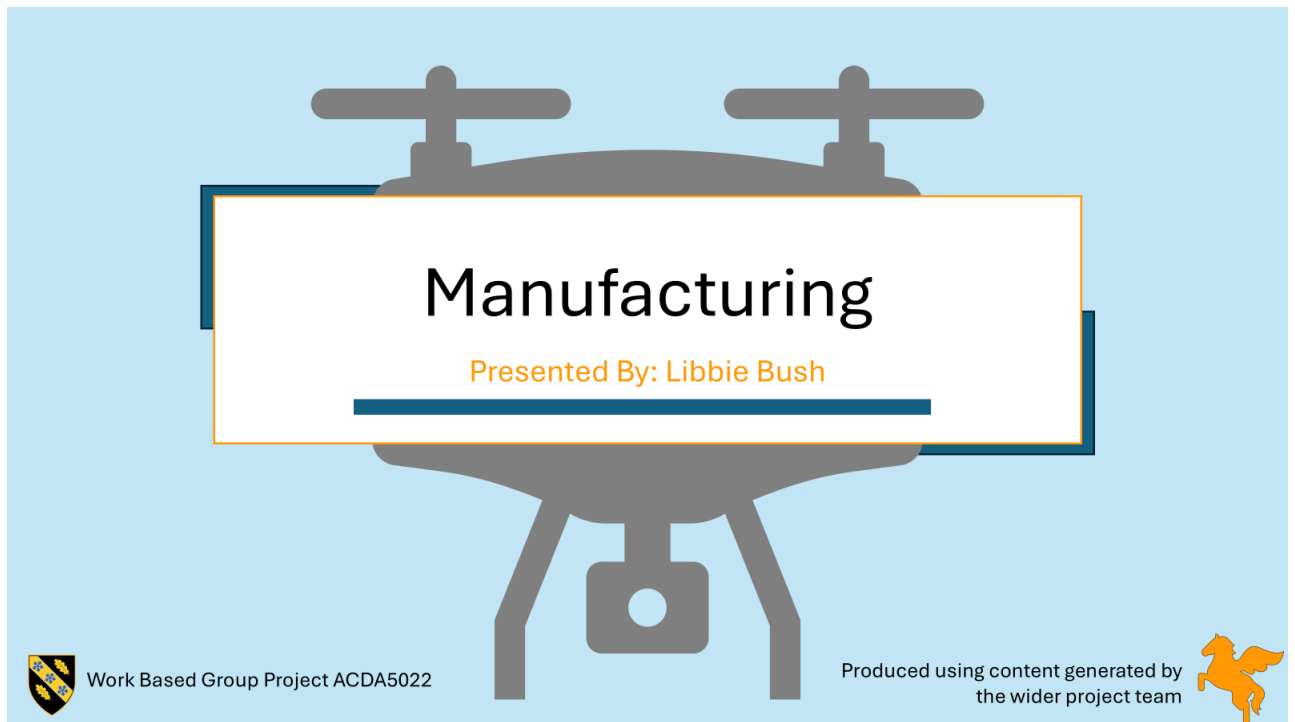
Slide 35 – Primary Sub-System Trials - Presented by Alex Lamdin

Complete System Trials

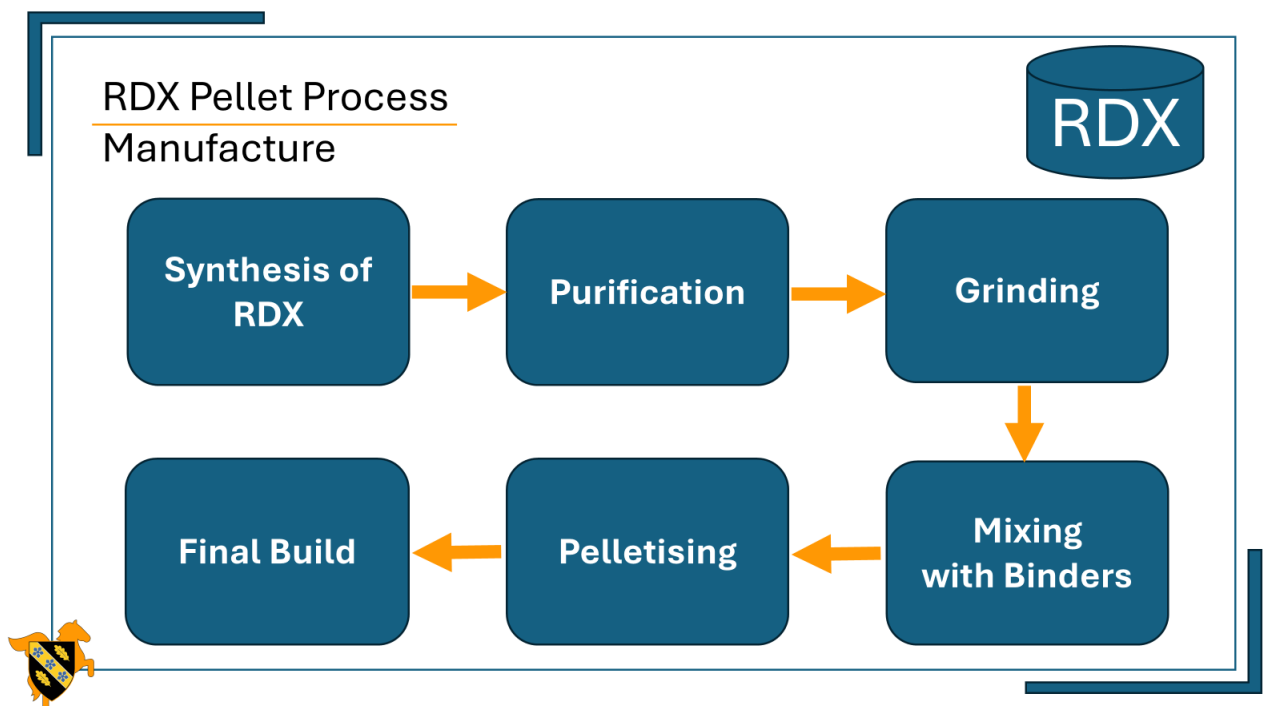
- ECM/EW Environment testing
- Complete System Range & Endurance Testing
- Completed system in packaging - UN Hazard Classification Testing
- **Representative Scenario "Field" Trials & Pre-Handover User Trials – Can they use it? Do they have any suggested improvements?**



Slide 36 – Complete System Trials - Presented by Alex Lamdin



Slide 37 – Manufacturing - Presented by Libbie Bush



Slide 38 – RDX Pellet Process Manufacture - Presented by Libbie Bush

Requirement Manufacture

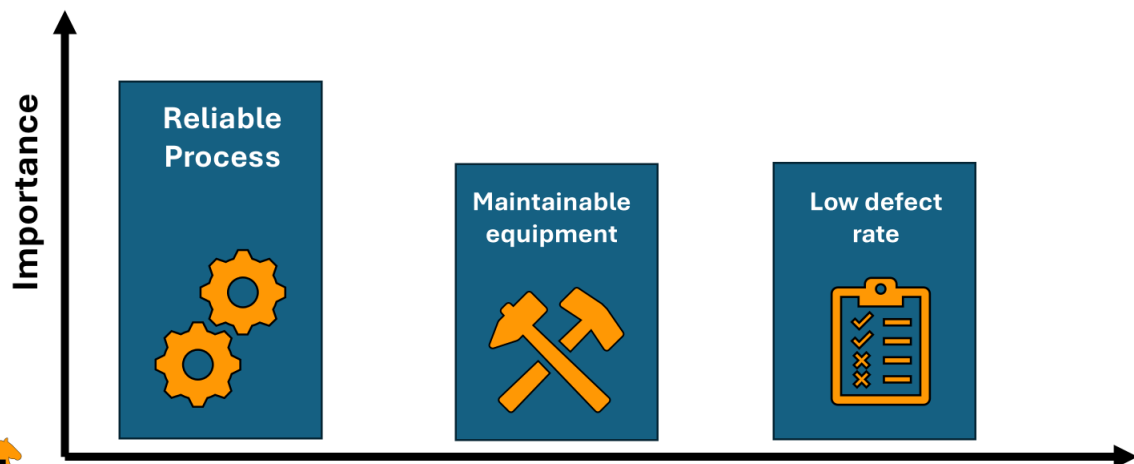
- Overall systems requirements
- Internal stakeholder requirements
- External regulators and legislation
- Identify hidden requirements



Slide 39 – Requirement Manufacture - Presented by Libbie Bush

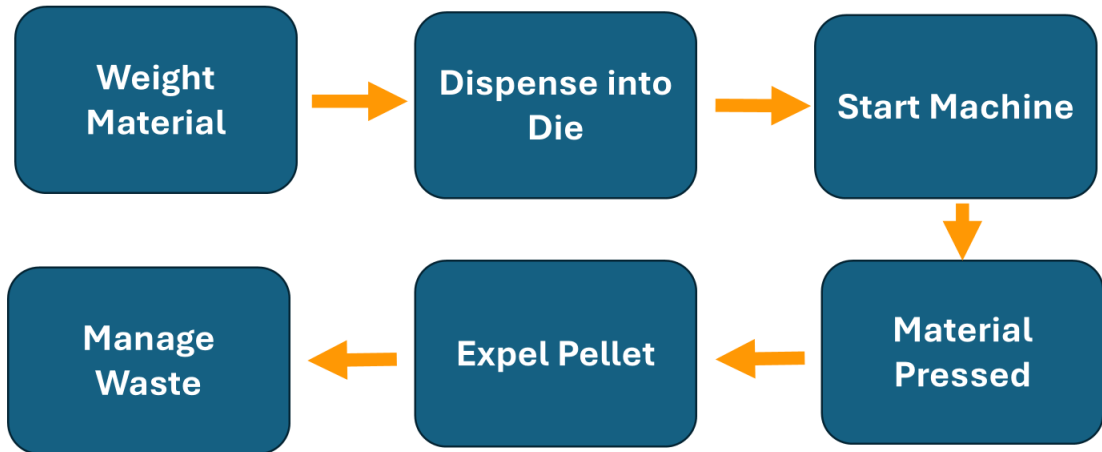
Requirements Gathering Manufacture

Results from Pairwise Comparison



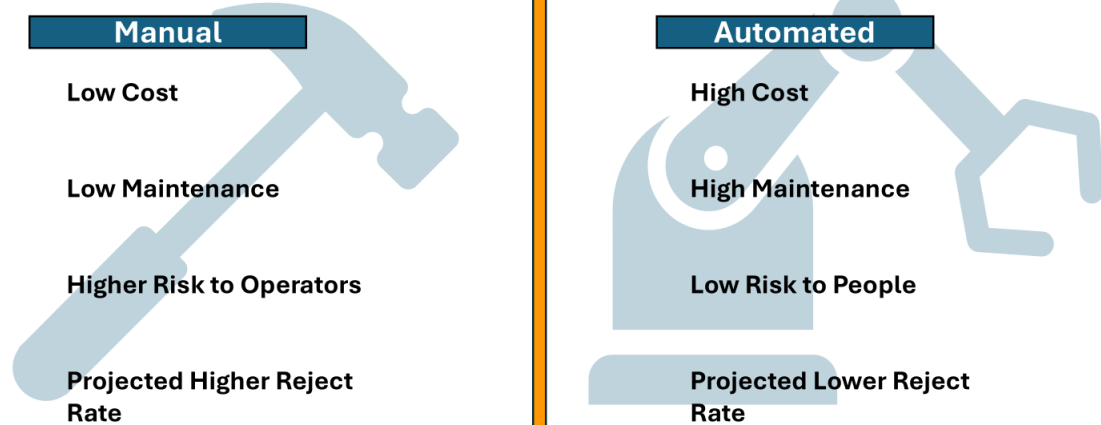
Slide 40 – Requirement Gathering Manufacture - Presented by Libbie Bush

Simplified Flow Manufacture



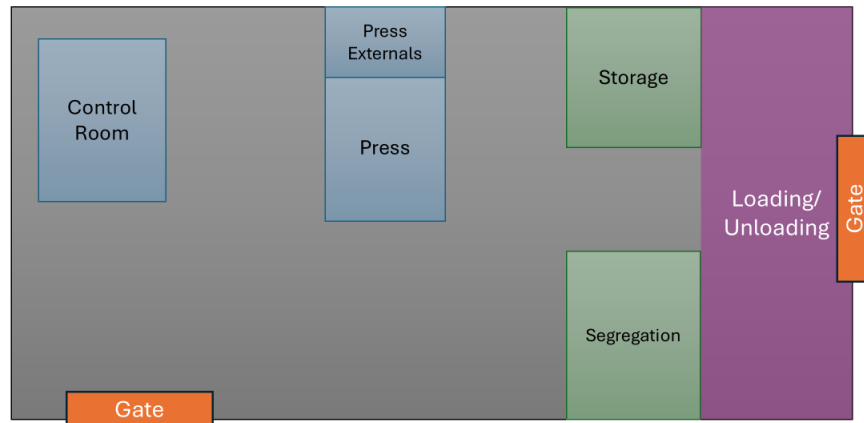
Slide 41 – Simplified Flow Manufacture - Presented by Libbie Bush

Design Choice Manufacture



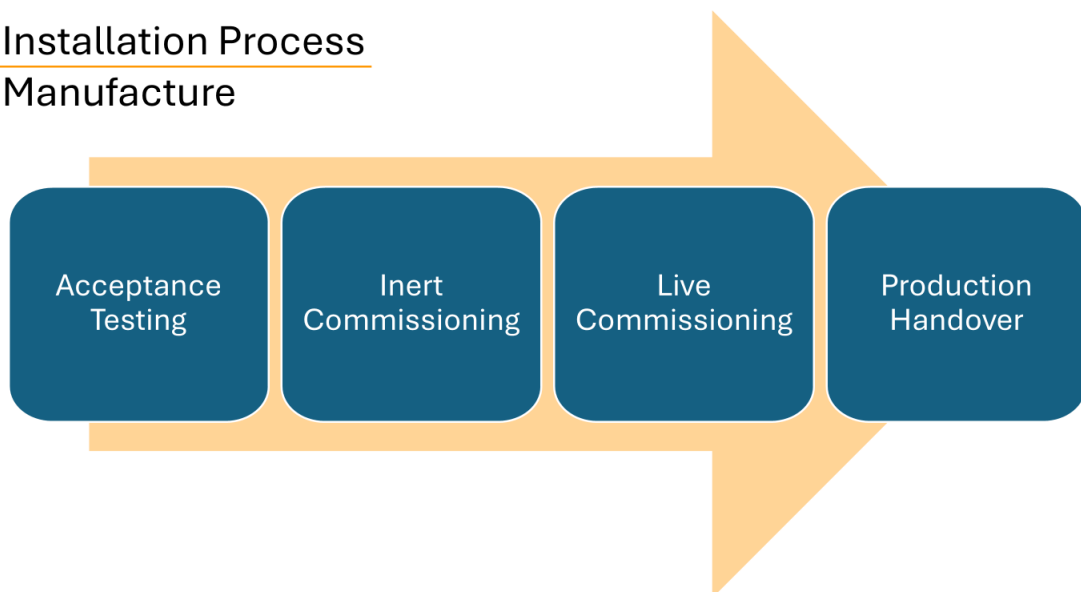
Slide 42 – Desing Choice Manufacture - Presented by Libbie Bush

Process Layout Manufacture

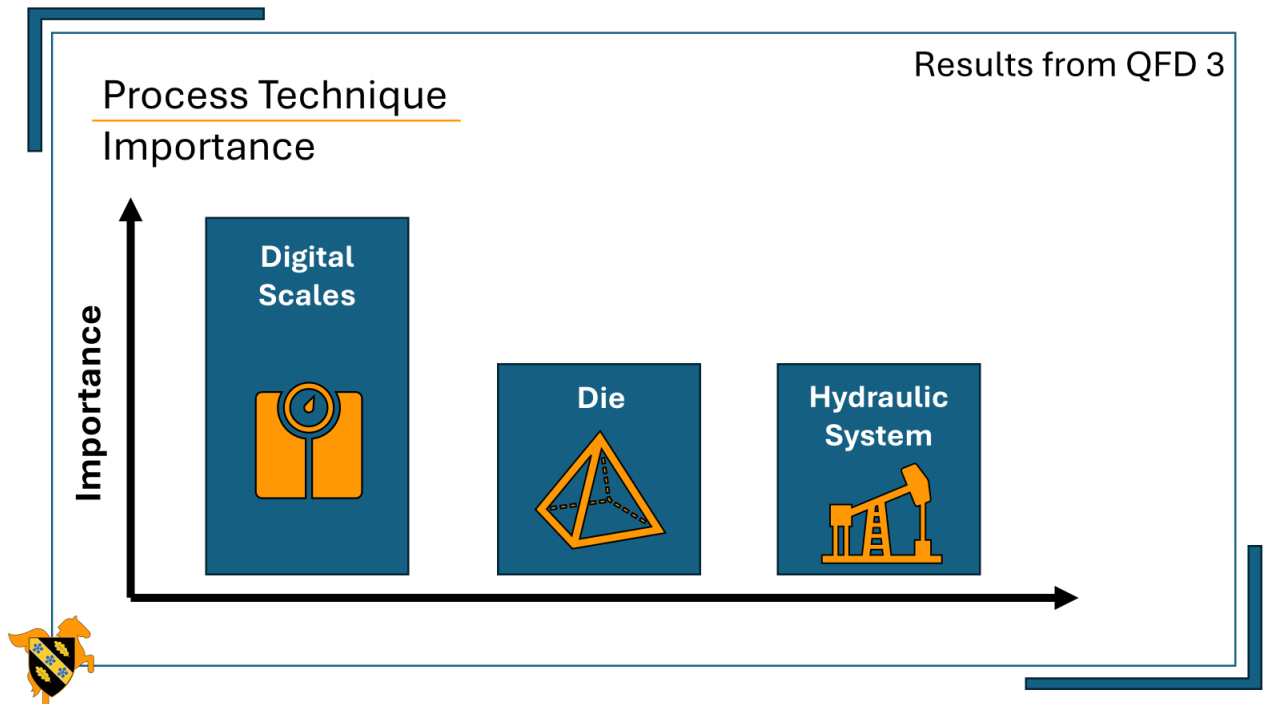


Slide 43 – Process Layout Manufacture - Presented by Libbie Bush

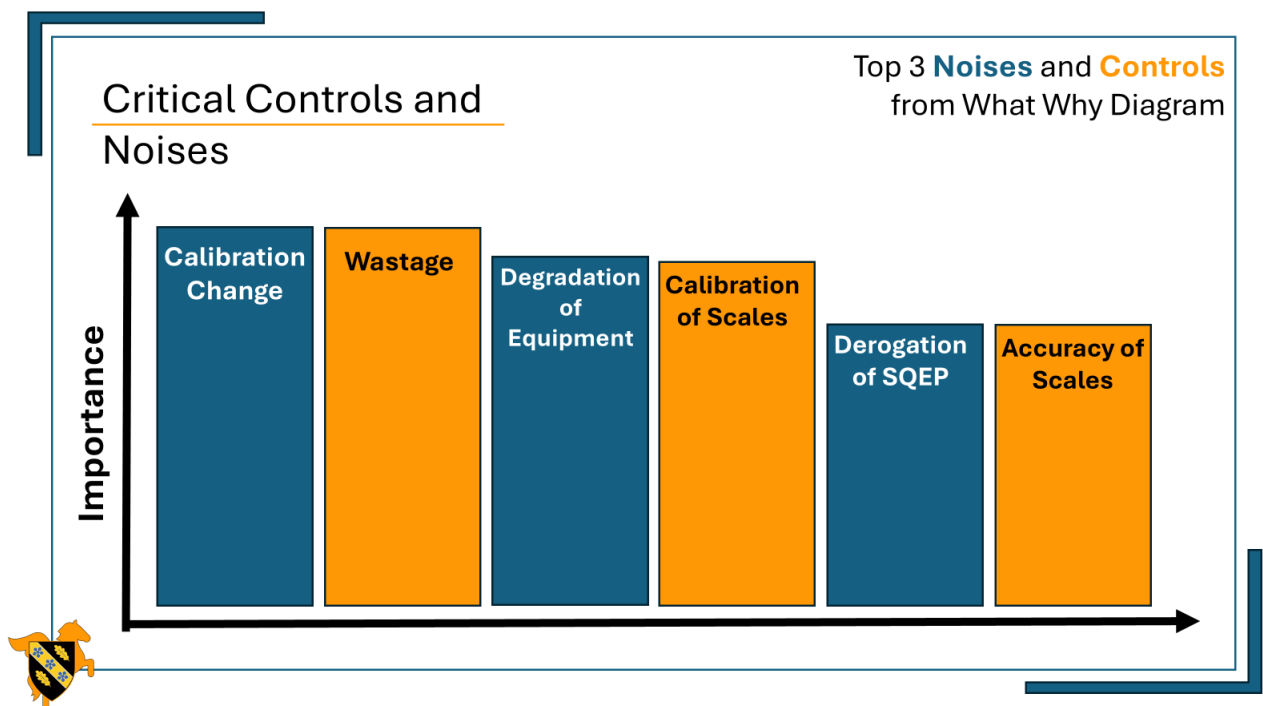
Installation Process Manufacture



Slide 44 – Installation Process Manufacture – Presented by Libbie Bush



Slide 45 – Process Technique Importance - Presented by Libbie Bush



Slide 46 – Critical Controls and Noises - Presented by Libbie Bush

Process Control Plan

Planned Maintenance



Prestart Checks



Calibration Checks



Regular Training



Slide 47 – Process Control Plan - Presented by Libbie Bush

Process Safety

Presented By: John Hamilton



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Slide 48 – Process Safety - Presented by John Hamilton

Safety Requirements for Manufacture

Processes must adhere to HSAWA 1974
Legislation, Explosive Regulation 2014 and
DSA 02 OME Regulation

Energetic processes shall be made safe
throughout the Manufacturing process

Non-energetic processes shall be made safe
throughout the Manufacturing process



Slide 49 – Safety Requirements for Manufacture - Presented by John Hamilton

Process Hazards

Explosive Hazards

➤ Electrostatic Discharge (ESD)
shock to RDX could cause
inadvertent detonation during
manufacture.



Control of Contraband



Correct Personal Protective
Equipment



Correct Working Environment



Slide 50 – Process Hazards (1) – Presented by John Hamilton

Process Hazards

Explosive Hazards

➤ Explosive Contamination could also cause inadvertent detonation during manufacturing processes.



Housekeeping Standards



Pre- and Post- Operation Clean down



Training of Competent People



Slide 51 - Process Hazards (2) - Presented by John Hamilton

Process Hazards

Health and Safety Hazards

➤ Trips, slips and falls could cause injury to personnel within the facility during manufacturing processes.



Housekeeping Standards



Communication of Potential Hazards



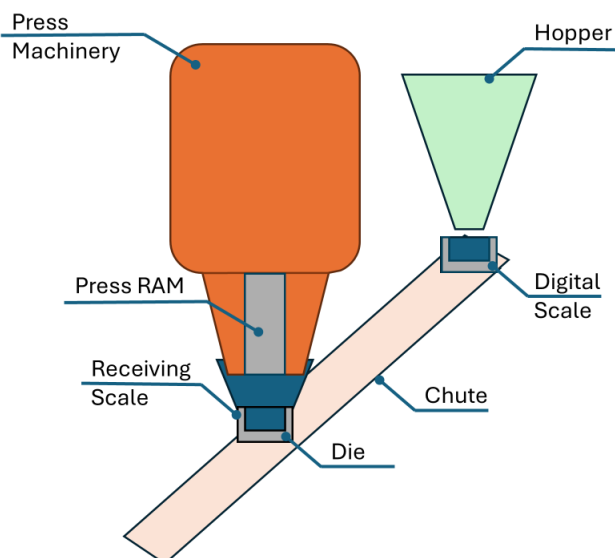
Prevention Methods



Slide 52 – Process Hazards (3) - Presented by John Hamilton

Press Process Hazards

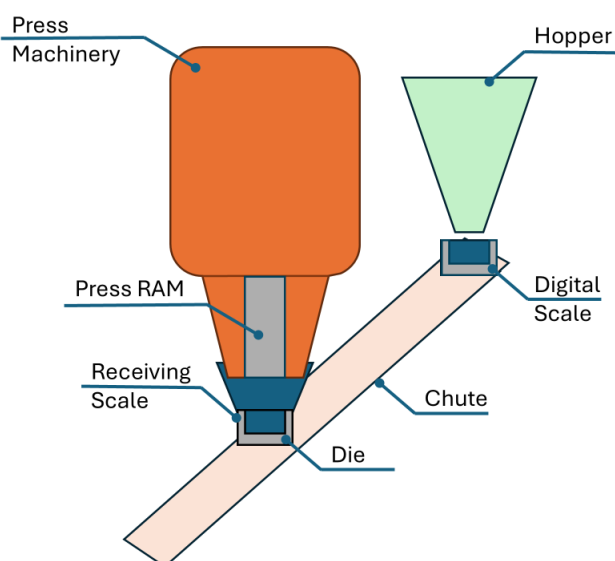
- Movement of explosive during the press process could potentially cause inadvertent detonation where there's moving parts of the pressing equipment.
- This hazard is present across the entire process of pressing material, and this is caused by RDX moving down the chute to the press.



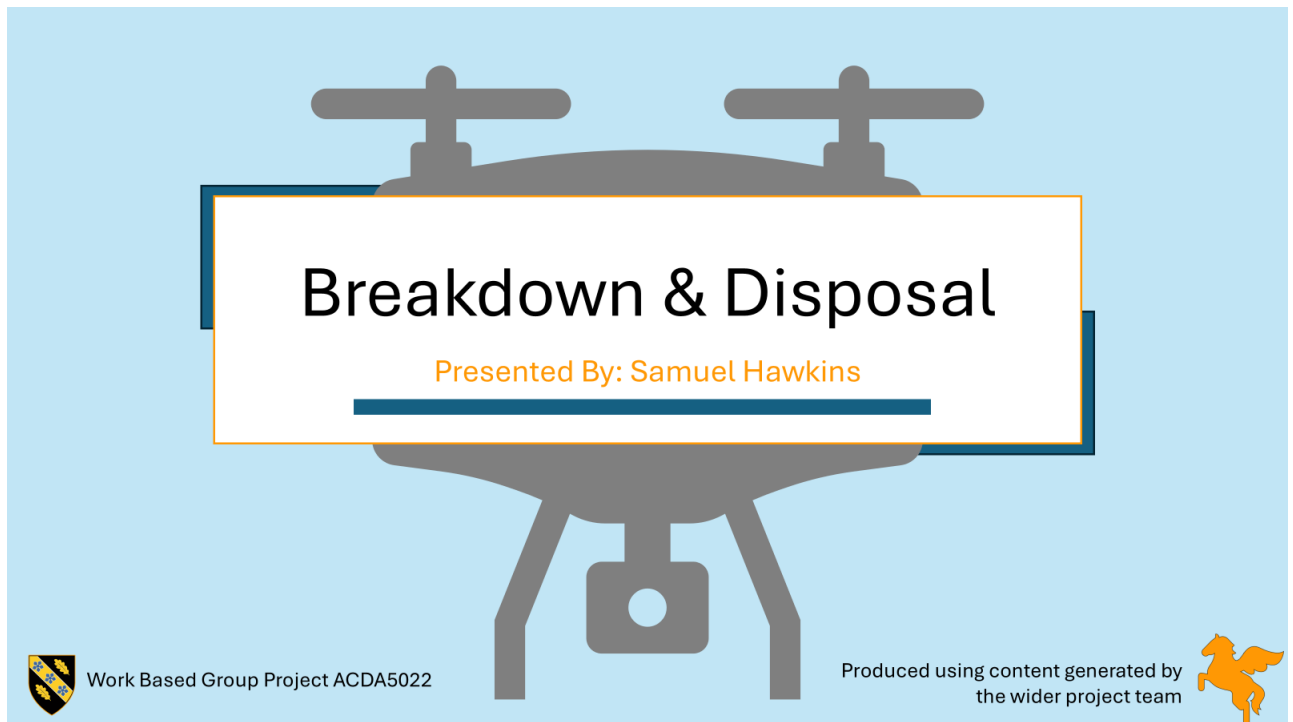
Slide 53 – Press Process Hazards - Presented by John Hamilton

Weighing RDX Hazards

- Overweighing the RDX could cause inadvertent detonation or potentially contamination of explosive compositions.
- This hazard would be present during the process of weighing the material and the risk of more RDX being transferred to chute therefore increases the risk of detonation due to heat from friction.



Slide 54 – Weighing RDX Hazards - Presented by John Hamilton



Breakdown & Disposal

Presented By: Samuel Hawkins

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Slide 55 – Breakdown and Disposal - Presented by Samuel Hawkins

How We Manage Waste Requirements

System Requirement	Manufacturer Requirement
“The Procurement Body, Logistics Body, Legislative Bodies and Manufacturer require that the system shall, at end-of-life, be capable of being broken down to a point where the remaining components can be safely disposed of.” <i>This would support the modular design implementation and subsequent sub-system requirements.</i>	“The Safety body require that system manufacturing shall minimise waste.” <i>This would go on to place processes and controls on the manufacturing process as seen in QFD 3 and 4.</i>



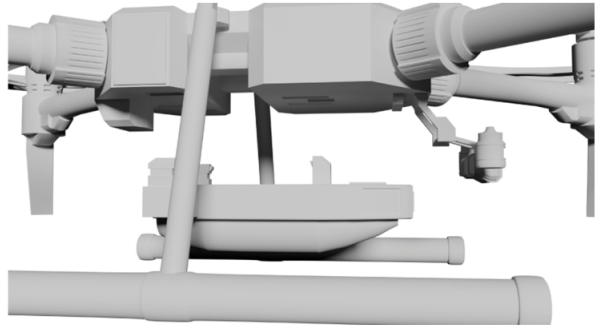
Slide 56 – How We Manage Waste Requirements - Presented by Samuel Hawkins

Designing for Disposal

Modular Design

Allows for separation of the warhead module from the remainder of the system.

- Warhead can be disposed of IAW with manufacturer options.
- Drone can be disposed of IAW end of life options.



Animations and models provided by L. Hartley

Slide 57 – Designing for Disposal - Presented by Samuel Hawkins

How We Manage Waste at Manufacture

Manage

Worker Traceability – Track any faulty batches to the operator and reasons for issues can be understood and addressed.

Training/Instructions – Following correct processes and applying training correctly can reduce/eliminate waste.

Defect Reporting – Throughout the weighing process, faults can be identified and resolved reducing possible waste.

Receipt Inspections – By inspecting the RDX when received, issues can be identified and addressed before carrying out subsequent processes.



Disposal Options

Segregation – Material need to be separated before carrying out the either of the following methods:

- **Burning** – Incinerator preferred over open air.
- **Chemical Destruction**



Slide 58 – How We Manage Waste at Manufacture - Presented by Samuel Hawkins

How We Dispose at End of Life

Resale – To governments who can purchase stockpile approaching OSD recouping cost.

Gifting – To governments in need reducing disposal burden.

Salvaging – Cannibalising the system and reusing components for other systems that can then be re-lifed.

Repair – After an incident, system can be repaired and re-lifed.

Abandoned in place – Can be detonated in situ or left as is.

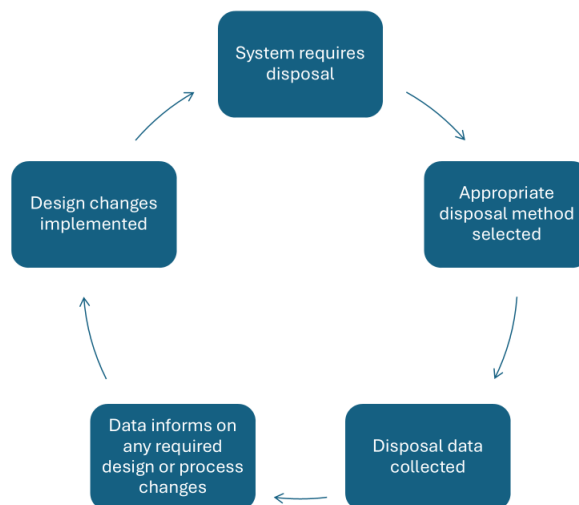
Self-Destruct – System flies to a set altitude and detonates.



Slide 59 – How We Dispose at End of Life - Presented by Samuel Hawkins

Disposal Data

As this is a new system yet to enter service there will be no disposal data available however, this captures the top-level approach.



Slide 60 – Disposal Data - Presented by Samuel Hawkins

Summary



Technical
Research and
Development



Product
Safety



Testing and
Evaluation



Manufacturing
Process



Process
Safety



Breakdown
and Disposal



Slide 61 – Summary - Presented by Samuel Hawkins

Questions?

Thank You



Work Based Group Project ACDA5022

Animations and models provided by L. Hartley



Slide 62 – Questions - Presented by Samuel Hawkins