

Development and Evaluation of a Risk-Tailored Systems Engineering Framework for Rapid Low-Cost Defence Effector Development

Research Proposal

BEng (Hons) Ordnance, Munitions and Explosives

ACCA6020 Independent Project

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Section	Brief target words	Word counts
Introduction/Aims & Objectives	150	153
Background/Literature Review	450	454
Project Design	200	193
Resources/Planning	200	201
Total proposal body	1000	1001

Table 1 - Proposal word-count alignment

Word counts above exclude title page, contents, table text and reference list.

1. Introduction, Aim and Objectives

This project will investigate whether traditional defence systems engineering can be tailored for rapidly developed low-cost defence effectors without losing the traceability, safety and assurance controls required in an Ordnance, Munitions and Explosives (OME) environment. The research question is: *“How can a risk-tailored systems engineering process improve speed, adaptability and design maturity when customer specifications are lean, evolving or influenced by rapidly changing operational need?”* The aim is to develop and evaluate a Rapid Assured Systems Engineering (RASE) framework by applying both a traditional document-based V-model route and the proposed rapid route to the same non-classified system-level case study. The comparison will consider how established systems engineering models can be drawn down into a lean model based systems engineering (MBSE) model to support accelerated development, while retaining sufficient evidence of requirements, functions, risks, design margins, manufacturability and verification logic.

Objective No.	Objective
OBJ-01	Review relevant systems engineering standards, MBSE literature, rapid development methods and defence innovation sources to identify which process elements can be tailored without reducing OME assurance.
OBJ-02	Define a bounded, non-classified case study with clear stakeholder needs, target value ranges, assumptions and system-level constraints.
OBJ-03	Apply established systems engineering models and draw them down into a lean MBSE representation to support accelerated development while preserving traceability between requirements, functions, interfaces, risks and verification evidence.
OBJ-04	Generate comparable systems engineering artefacts for both approaches, including requirements, functional architecture, traceability, verification planning and risk-gated decision evidence.
OBJ-05	Use modelling or structured trade-space analysis to identify design-margin sensitivity, including where small changes in target values may create disproportionate effects on system suitability or failure threshold.
OBJ-06	Incorporate modular design considerations to assess how interchangeable or scalable system elements could support faster iteration and controlled reconfiguration.

OBJ-07	Apply design-for-manufacture considerations to assess whether the proposed system architecture can be realistically produced, assembled, inspected and controlled within a low-cost rapid-development context.
OBJ-08	Apply P-diagram methodology as a vital part of the framework to capture intended inputs, control factors, noise factors, external effects, error states and response variables, preventing a one-size-fits-all process from overlooking significant sources of variation.
OBJ-09	Introduce a controlled requirement, target value, modularity or manufacturability change to assess how each approach responds to evolving customer need or design constraint.
OBJ-10	Evaluate both approaches using weighted criteria covering speed, requirement quality, traceability, adaptability, design-margin awareness, manufacturability, robustness to noise factors and assurance control.
OBJ-11	Produce a final framework, comparative evidence matrix and implementation recommendations identifying where rapid systems engineering should be used alongside conventional assurance-led processes.

Table 2 – Project Objectives

2. Background to the Proposed Research / Literature Review

Systems engineering translates stakeholder needs into validated system solutions through structured life-cycle processes, requirements definition, architecture, verification and validation. ISO/IEC/IEEE 15288 provides a life-cycle framework for systems, while ISO/IEC/IEEE 29148 addresses requirements engineering and the need for clear, traceable and verifiable requirements [1], [2]. The INCOSE Systems Engineering Handbook reinforces technical management, configuration control and evidence-based decision making across complex system development [3]. These principles remain essential to OME practice because safety, legality, security, compliance and assurance cannot be removed from defence engineering. This project concerns tailoring rather than replacing systems engineering.

The rationale for this work is the changing character of capability development. The Russo-Ukraine conflict has demonstrated the operational value of low-cost uncrewed systems, one-way effectors, rapid field adaptation and massed attritable capability. UK defence policy recognises that uncrewed systems are strategically important and that defence must accelerate access to innovative technology [4]. Cost-exchange analysis highlights how inexpensive Shahed-type drones can impose disproportionate defensive cost and force expensive interceptors to be used against cheaper threats [5]. RUSI similarly identifies mass, autonomy and uncrewed systems as pressures on traditional force design [6].

A second driver is requirement maturity and strategic urgency across Europe and NATO. Defence customers may need industry to respond to emerging land-war, air-defence and counter-UAS pressures before a full acquisition specification has stabilised. The UK Parliamentary Office of Science and Technology notes that the Strategic Defence Review 2025 outlined approaches for simplifying and speeding up innovation, including UK Defence Innovation and a £400 million annual budget to streamline delivery to the armed forces [7]. At European level, the proposed AGILE fund allocates €115 million to accelerate disruptive defence

technologies, particularly through SMEs, start-ups and faster movement from concept to fielded capability [8]. RUSI's seminar on innovation and great power competition adds that civil and defence innovation ecosystems must reinforce one another as competitor approaches to civil-military fusion gather pace [9]. These sources indicate that rapid innovation is becoming a policy priority, not only an operational observation.

This matters because urgent capability work often starts with capability gaps, threat observations, field feedback, prototype evidence and supply-chain constraints rather than complete contractual specifications. Other industries provide useful but imperfect comparators. Commercial space, automotive electric vehicles and consumer electronics use model-based methods, digital twins, rapid prototyping and short feedback loops to compress development time. MBSE can improve change impact analysis because requirements, functions, interfaces and verification evidence can be linked within a model rather than static documents. However, defence cannot simply copy commercial practice because OME systems involve higher consequence, regulation and security constraints. The academic contribution is to test whether selected rapid methods can be integrated with risk-gated assurance for low-cost defence effectors rather than exquisite long-life systems.

Industry	Primary methodology	Speed to market	Key advantage
Commercial space	Agile MBSE and prototyping	Months	Hardware-in-the-loop update cycles and rapid mission learning
Automotive EVs	Digital twins and MBSE	1-2 years	Software-led validation and over-the-air feature development
Consumer electronics	Agile hardware and DevOps	Weeks to months	Fast physical-to-digital feedback and short product cycles
Defence industry	Document-based V-model	5-20 years for major programmes	High assurance, regulation, safety and security control

Table 3 - Cross-industry rapid engineering comparison

3. Experimental Design

The project will use a pragmatic applied research approach because the intended output is a usable engineering method, with a research method following Saunders et al.'s research onion [10]. A non-classified representative low-cost effector problem will be defined at system level. The same initial capability need will be processed through two routes: a traditional document-based V-model route and the proposed RASE route.

The controlled test will be a mid-process change event, such as a reduced unit-cost ceiling, loss of a key component, revised portability constraint or change in end-user priority. Both routes will be assessed on the effort required to respond to that change and on output quality. Data will include usable requirements, traceability completeness, unresolved assumptions, assurance gates retained, supply-chain considerations identified and estimated rework. Evaluation will use a weighted matrix covering speed, requirement quality, traceability, adaptability, supply-chain realism, assurance control and suitability for OME use. Limited expert review may be used if employer approval and ethics requirements allow.

3.1 Outline of Experimental Procedure

1. Build the literature and standards baseline for traditional and rapid systems engineering.
2. Define the non-classified case study, stakeholder need, operating assumptions and initial constraints.

3. Apply a traditional V-model route and generate requirements, architecture, traceability and verification artefacts.
4. Develop the RASE framework and generate equivalent artefacts for the same case study.
5. Introduce the same controlled change event to both approaches.
6. Evaluate outputs using the weighted matrix and record conclusions.

Artefact	Traditional route	RASE route
Requirements	Fuller fixed baseline requirement set	Minimum viable, prioritised and tradeable requirement set
Architecture	Sequential functional decomposition	Mission-thread or effect-chain architecture
Traceability	Document-based matrix	Lean model-linked traceability matrix
Verification	Full V-model verification plan	Risk-gated early verification plan
Change impact	Manual change review and document update	Traceability-led impact review and rapid re-baseline

Table 4 - Comparative systems engineering artefacts

3.2 Data Collection and Evaluation

Criterion	Example measure	Purpose
Speed	Effort, hand-offs and artefact-generation time	Tests suitability for rapid development
Requirement quality	Clear, testable and prioritised requirements	Tests control of immature requirements
Traceability	Links between needs, functions, risks and tests	Tests assurance evidence
Adaptability	Effort after change event	Tests response to evolving threats or user need
Supply-chain realism	Availability and lead-time considerations identified	Tests design feasibility under constrained supply
Assurance control	Safety, compliance and verification gates retained	Tests OME acceptability

Table 5 - Evaluation criteria

3.3 Risks, Limitations and Ethical Issues

The project will remain at system level and will not include energetic testing, detailed weapon design, detailed warhead design, target vulnerability assessment, guidance-law design or a deployable system specification. Any case-study assumptions will be recorded and reviewed to ensure the work remains suitable for academic submission and employer approval.

4. Resources and Planning

The project is achievable within the WBP timescale because it requires analytical development, modelling and process evaluation rather than physical manufacture or energetic testing. Physical resources will include a laptop, Microsoft Office, spreadsheet software, UWTSD library access and an approved modelling or diagramming tool such as Capella, Cameo, Enterprise Architect, Visio, draw.io or an employer-approved alternative. Human resources will include the academic supervisor, employer sponsor or line manager, and optional engineering, manufacturing, safety or assurance reviewers. Other resources will include public

standards, journal papers, government strategy documents, defence analysis, approved non-sensitive workplace process knowledge, a project logbook and any permission-to-publish process required by the employer.

Key risks are classification restrictions, subjective weighting of evaluation criteria, excessive scope and limited access to current industrial data. These will be controlled by using open-source and approved information, keeping the case study at system level, recording assumptions, and agreeing boundaries with the supervisor and employer. No medical data, vulnerable groups or sensitive personal data are expected. If expert feedback is used, participation will be voluntary and anonymised. The Gantt chart below allocates early effort to literature review and case-study definition, followed by traditional-route application, RASE development, comparative evaluation, report writing and viva/poster preparation.

Task	Jun	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar
Proposal submission	X					
Literature review and standards baseline		X	X			
Case-study definition			X			
Traditional SE application			X	X		
RASE framework development/application				X	X	
Evaluation, discussion and recommendations					X	
Report finalisation, poster and viva preparation					X	X

Table 6 - Indicative Gantt chart

5. Reference List

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- [10] M. N. K. Saunders, P. Lewis and A. Thornhill, Research Methods for Business Students, 9th ed. Harlow: Pearson, 2023.
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