STPA for eVTOL Operations

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eVTOL Safety Leadership Group

The eVTOL Safety Leadership Group (eVSLG) was established in 2022 and seeks to emulate the Offshore Helicopter Safety Leadership Group.

The aim of the eVSLG is to create and maintain an **open safety culture** between all members of this nascent sector's ecosystem.

Membership includes OEMs, operators, infrastructure owners, NATS, and government bodies such as the Air Accident Investigation Branch.

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Project Statement

Ensure the safe deployment of eVTOL aircraft in the United Kingdom airspace by considering the complex interactions between the various actors in the eVTOL ecosystem – Regulator, eVTOL Operators, Vertiport Operators, OEMs, and Air Navigation Service Providers.

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Why STPA for eVTOL Operations?

Integrating a **novel technology like eVTOL** into the current air navigation system can pose **emerging risks** and **hazards**, which can be effectively identified using **systems thinking-**based **STPA**.

Due to the potentially large number of requirements that need to be implemented imminently, identifying and managing these requirements has brought challenges.

A novel severity, control impact, and expert judgement-based **prioritisation method** was developed as part of this work to rank the STPA results.

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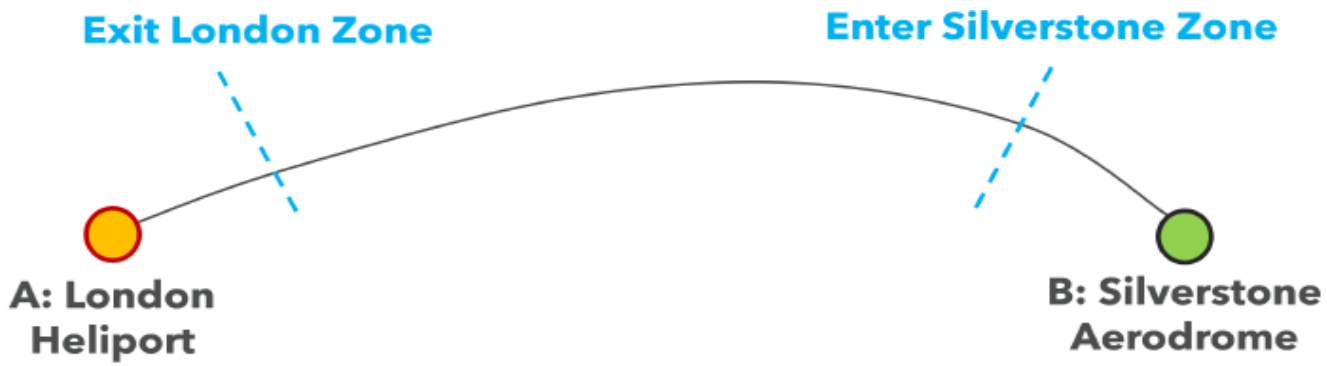
The CAA's aims

The CAA's aims for this exercise were twofold:

1. To **validate** Systems Theoretic Process Analysis as a technique for examining complex systemic aviation risks, complementing the CAA's current suite of tools, e.g., Bow Tie.
2. To utilise STPA to undertake a systemic hazard analysis for **conventional helicopters and electric vertical take-off and landing aircraft.**



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STPA for eVTOL Operation - Phases

Phases

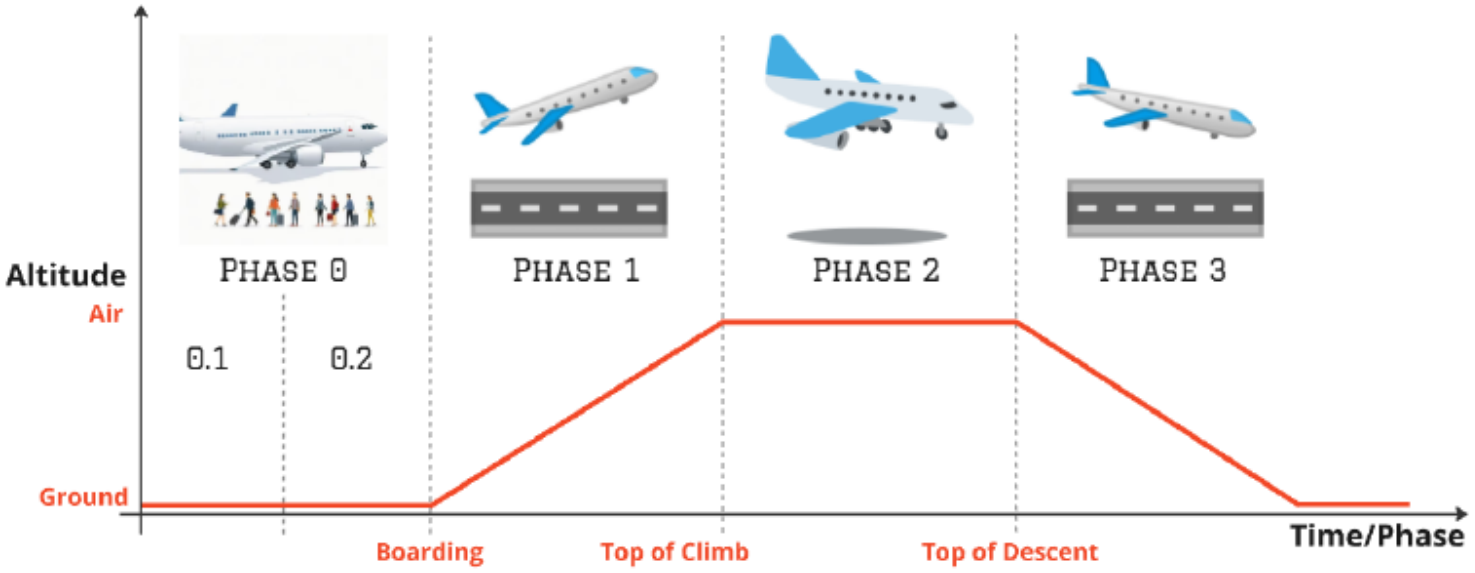
0.1: Organisational (Regulatory Preparation)

0.2: Operational (Operational Preparation)

1: Operational (Take Off)

2: Operational (Cruise)

3: Operational (Start of descent to completion of landing)



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STPA for eVTOL - TIMELINE

UK Civil Aviation Authority

WMG THE UNIVERSITY OF WARWICK

Project Kick-Off

June 24

STPA Step-1

July 24

5 Losses covering safety-critical and non-safety-critical ones.

STPA Step-2

Aug 24

5 control structures (organisational and operational)

STPA Step-3

Oct 24

317 UCAs (110 High priority UCAs)

STPA Step-4

Jan-Feb 25

432 Requirements (124 High priority requirements; 56 Gaps)

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Results

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STPA Step 1

5 losses were identified and ranked by the stakeholders

ID	Losses	Ranking
L-1	**Human Loss:** Loss of life or injury to 1st, 2nd or 3rd parties	1
L-2	**Material Loss:** Loss of or damage to the eVTOL or surrounding item / property / infrastructure	2
L-3	**Mission Loss:** Loss of transportation mission	3
L-4	**Consumer Demands Loss:** Loss of customer satisfaction or public confidence in eVTOL	4
L-5	**Business Goal Loss:** Loss of business goal of eVTOL Operator	5

Note: 1st party- eVTOL crew, 2nd party - passengers and 3rd party- any one external to the eVTOL

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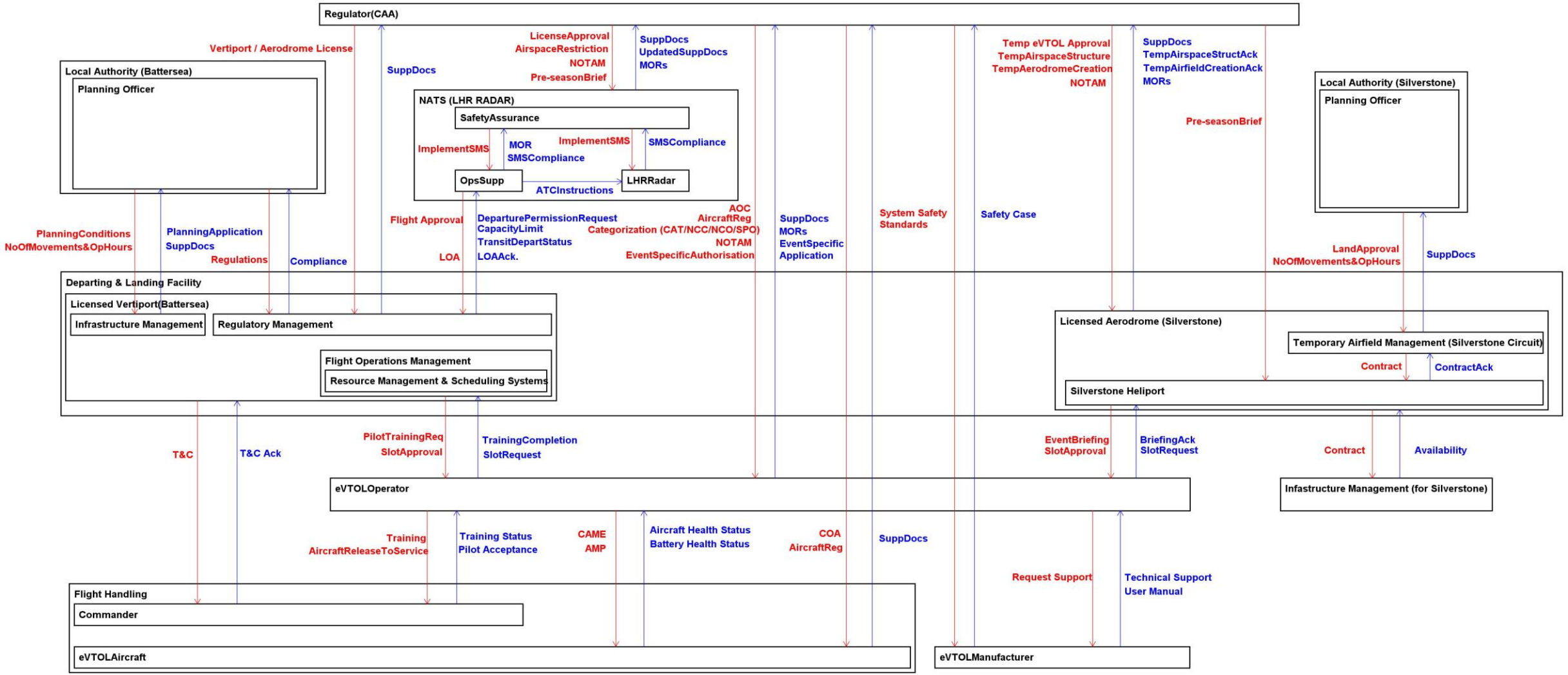
STPA Step 2 – Control Structures

Phase 0.1 - Regulatory Preparation for the Flight



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Prioritisation of UCAs & Requirements

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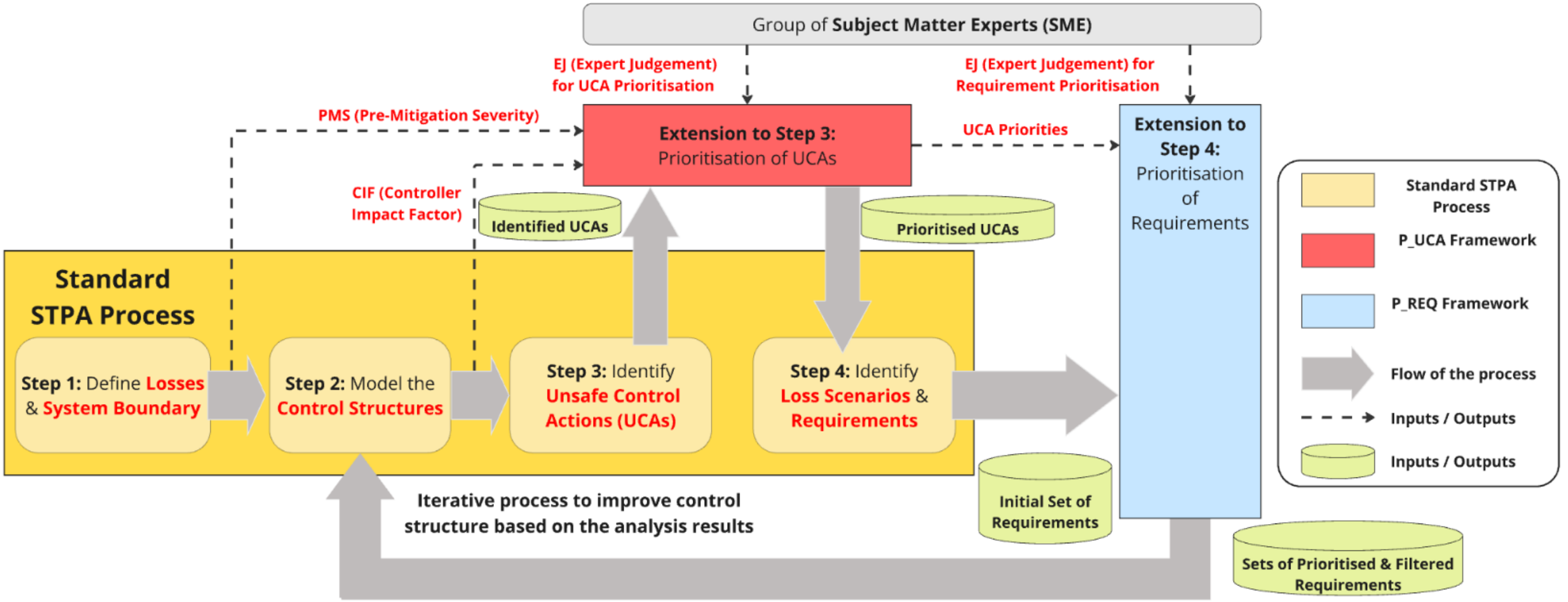
STPA Extensions for Prioritisation



UCA Prioritisation Journal Article- http://bit.ly/3VnMetm;
Requirement Prioritisation Journal Article- - https://bit.ly/45DwJTY

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Statistics of Results

Phase	Step-3		Step-4		
	Total No of UCAs	Number of P1 and P2 UCAs	No. of Causal Factors	Total No. of Req	No. of P1 & P2 Requirements
Phase 0.1	124	53	219	234	**124** [Regulator-57, Vertiport Operator-36, eVTOL Operator–15, Air Navigation Service Provider-16]
Phase 0.2	47	7	34	35	
Phase 1	75	31	92	97	
Phase 2	37	15	50	61	
Phase 3	34	4	5	5	
Total	**317**	**110**	**400**	**432**	

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Gap Analysis

- **Identify ‘Gaps’ based on the STPA Analysis**
  - Confirm whether the identified STPA requirements are ‘gaps’ in the current aviation **regulations/policies/procedures**.
- **56 Gaps** were identified that cover various aspects such as
  - Organisational performance & Process review
  - Assessment criteria, Acknowledgement, and Confirmation for certifications
  - Training process for individuals involved in the regulatory process
  - Collision and Energy management, Automation and Simulation, etc.

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Gap Analysis - Summary

Stakeholder	Unique high-priority requirements	No of Gaps identified	Gaps applicable to both eVTOL & current helicopter operations
Regulator	57	17	11
Air Navigation Service Provider	36	8	8
eVTOL Operator	15	2	
Vertiport Operator	16	29	8
Total	**124**	**56**	**27**

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Gaps

Stakeholder	Gap	Recommendation Type
Regulator	The regulator shall be properly trained to review the supplementary documents regarding categorisation (CAT/NCC/NCO/SPO) correctly.	Procedures
Air Navigation Service Provider	ANSPs should implement mechanisms to detect and alert controllers/service providers to deviations in aircraft performance (e.g., altitude, speed, trajectory) from expected parameters	Procedures
Air Navigation Service Provider	ANSPs should maintain sufficient numbers of trained and licensed personnel to manage air traffic services and respond to operational demands	Procedures
eVTOL Operator	Process review of the relevant team issuing 'Aircraft Release to service' within the eVTOL Operator shall be conducted periodically to ensure that the team operates properly and safely.	Regulations
Vertiport Operator	Licensed Aerodrome shall implement automated systems that periodically validate Feedback loop between eVTOL and the aerodrome about airspace capacity.	Procedures
Vertiport Operator	Local Authority shall ensure that the proposed 'No of Movement & Op Hours ' are properly communicated with Temporary Aerodrome Management.	Policy

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Next Steps

- Where regulatory changes are required, we will work with the CAA's Rulemaking team to convert the study into aviation legislation. This process typically takes two years to complete. This timeframe coincides with the government's roadmap for initial eVTOL commercial operations.
- Significant number of other lower priority considerations will be followed up collaboratively with industry, through the eVSLG Risk Sub-Group

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Publications

- **Civil Aviation Publication(CAP) Report 3141 -** https://bit.ly/412llhP
- **Journal Article on UCA Prioritisation -** http://bit.ly/3VnMetm
- **Journal Article on Requirement Prioritisation -** https://bit.ly/45DwJTY

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Thank you.

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