Part 4: Systems Engineering

Task 1: System Level Requirement

ID	Requirement Text	Rationale Text	Verification Type	Verification Plan
P-1	The TUAV system shall have a radio transmission range of 14km.	Statistical Analysis shows that for 14km the probability of the system working is 95.8% according to the data given.	Testing	Find the point where the transmission becomes weak while moving the receiver away from the transmitter. It should be greater than 14km.
P-2	The TUAV system shall hover for a mission endurance of 2 hours.	Data in the brief shows that each SARH mission is 2 hours.	Testing	Record the flight time for a test flight and ensure it can endure 2 hours of flight.
P-3	The TUAV system shall hover at an altitude of 300 m.	Using the data, it is shown that for an altitude of 300 m, the CDF shows a probability of 0.99.	Testing	Testing the hover capabilities at the maximum required altitude.
P-4	The TUAV system shall have a reliability of 0.999.	The radio relay sub-system has a reliability of 0.999 and the TUAV system depends on this.	Analysis	Calculate the failure rate to find the reliability of the system.
E-1	The TUAV system shall operate at a maximum windspeed of 17m/s.	Comparing the Douglas Sea State with the Beaufort Scale, the maximum wind speed for the worst sea state of 6 is 17m/s. [17] [18]	Testing	Test the system in a wind tunnel with speeds up to 17m/s.
E-2	The TUAV system shall operate at a minimum temperature of 0°C.	South England’s mean temperature data shows that it goes to 0°C near coastal areas [19].	Testing	Carry out tests on the components of the TUAV system at 0°C.
E-3	The TUAV system shall operate at a maximum temperature of 40°C	Most electric components have a max temp of 40°C [20].	Testing	Carry out operational tests at 40°C.
I-1	The TUAV aerial platform shall be stored in the storage envelope of 0.5x0.5x0.5 in the ILB.	This is so that the aerial platform can fit onboard the ILB.	Inspection	Measure the dimensions of the aerial platform to ensure it does not exceed the 0.5m limit on the length, width, and height.
I-2	The tethering equipment shall be stored in the storage envelope of 0.25x0.5x0.25 in the ILB.	So that the tethering equipment can be fitted onboard the ILB.	Inspection	Measure the dimensions of the tethering equipment to ensure it does not exceed 0.25m in length and height, 0.5m in width.
I-3	The battery shall be stored in the storage envelope of 0.25x0.25x0.25 in the ILB.	This is so that the battery can fit onboard the ILB to provide power to the TUAV.	Inspection	Measure the dimensions of the battery to ensure it does not exceed the 0.25m limit on the length, width, and height.
V-1	The TUAV system shall operate beneath vibration of 8.5g and 5-10 Hz	To ensure the safety of the personnel onboard the ILB, the system shall not exceed the requirements stated.	Testing	Test the acceleration frequencies by launching the TUAV from the ILB at different sea states.

Task 2: Tethering Sub-System Functional and Architectural Description

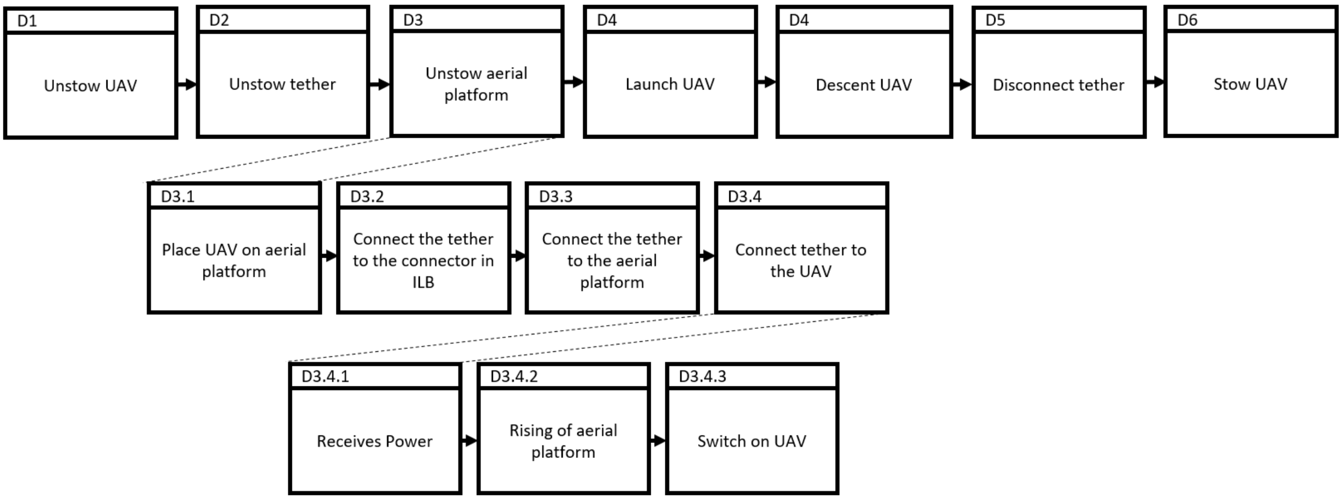

Figure 4.2.1: Functional Flow Block Diagram of the Tethering Sub-System

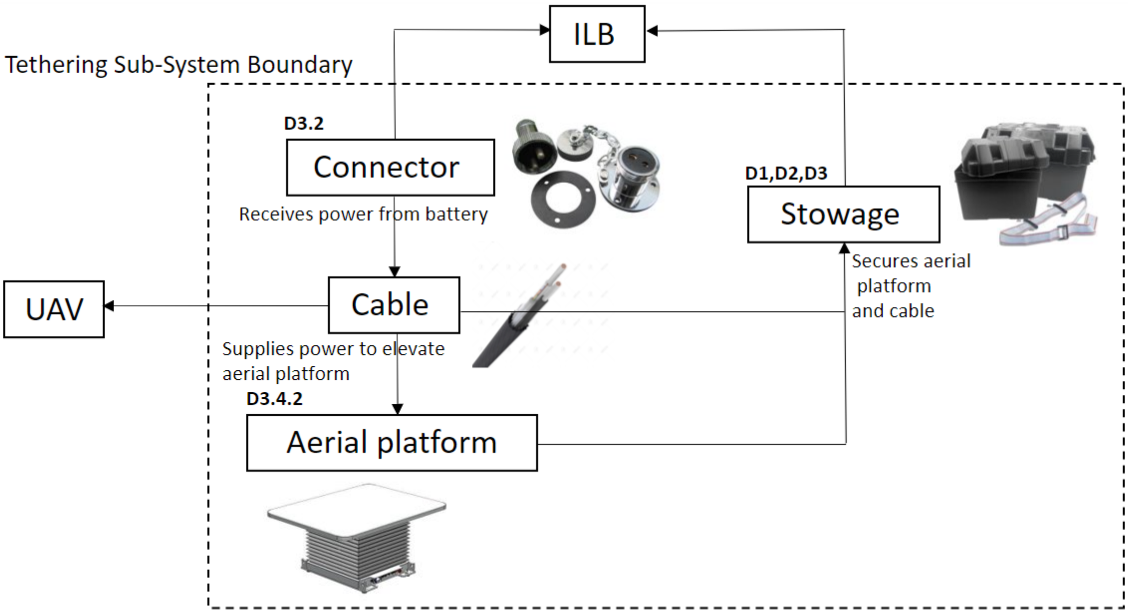

Figure 4.2.2: System Architecture of Tethering Sub-System with labels relating back to the FFBD

Table 4.2.1: FMECA of Tethering Sub-system

Sub-system	Failure mode	Effect	Affected sub-system	Occurrence	Severity	Detectability	RPN
Tether	Stowage failure	Slight damage of the sub-system/damage during transport	UAV	2	3	5	30
	Knotted tether	UAV cannot reach required altitude	UAV	4	3	2	24
	Rupture of tether	Loss of UAV	UAV	3	5	4	60
	Connector disconnects from ILB	Power loss in UAV	UAV	4	5	5	100
	Aerial platform does not rise	Take off from lower height	Radio	4	5	4	80

Task 4: System Trade-off Study

Table 4.4.1: Trade-off Study of the 3 proposed system architectures

Metric	Weighting	TUAV	SATCOM	Fixed Wing UAV
Cost	0.3	4 [1.2]	1 [0.3]	3 [0.9]
Bandwidth	0.4	2 [0.8]	5 [2.0]	2 [0.8]
Ease of infrastructure implementation	0.2	3 [0.6]	4 [0.8]	1 [0.2]
Reliability	0.1	4 [0.4]	2 [0.2]	4[0.4]
Score MOP		**3.0**	**3.3**	**2.3**

Table 4.4.2: Definition of max/min score ranges

Metric	Scores	Definitions
Bandwidth	1	Low bandwidth means less data transmission for a given time
	5	High bandwidth means more data transmission
Cost	1	Higher cost of system overall
	5	Lower cost of system overall
Reliability	1	System has overall lower frequency of maintenance
	5	System has overall higher frequency of maintenance
Ease of infrastructure implementation	1	Build completely new infrastructure for the system
	5	Can use existing infrastructure with less modifications

Definition & justification of metric: Installation cost, bandwidth, infrastructure implementation and reliability were the four metrics chosen to compare the three different systems. Installation costs are the costs incurred for implementing the system. This includes the capital expenditure (CAPEX), and the operational costs of the system (OPEX). Cost is important metric because the organisation has a budget to spend on this project that needs to be followed. Bandwidth is defined as the amount of data travelled in between communication channels. A higher bandwidth will increase the performance of communications as more data is being transferred in a given amount of time. High bandwidths provide enhanced situational awareness due to more information such as precise location data and incident details being relayed. Reliability is defined as the amount of maintenance the system needs to function efficiently. Reliability is required in every system as functionality reduces with each usage. Needing regular maintenance costs more and reduce the systems lifespan Reliability is important because this system is used in critical applications and needs to operate without failures or malfunctions. By frequently maintaining, the system reliability can be increased. Infrastructure implementation is an essential category as these systems need various modification of the current system. It is defined as the ease of building or modifying new infrastructure in the existing one. Infrastructure implementation was chosen because changes need to be made to the existing lifeboat stations and implementing a new system will incur additional costs and training to the search team. The score for each metric is shown in Table 4.4.2; a higher score means it is better for the system in terms of that specific metric.

Definition and justification of weighting: The highest weighted metric was chosen by assessing what satisfies the customer requirements the most which is increasing the bandwidth of the system. This is because increased bandwidth is marginally prioritised over costs in MSAR missions according to the stakeholders. Following this, cost of the whole system is the next highest metric as the company needs to be able to afford the purchase and upkeep of the system chosen. Ease of infrastructure implementation is the 3rd highest metric as there are tests that need to be carried out to ensure the infrastructure of the system passes the respective tests and it also costs money to build a whole new infrastructure. The reliability is the last metric because it is still an important metric however it is already taken into consideration in the RBD so this reliability is mainly the maintenance of the system.

The trade-off study shows that the SATCOM has the highest score MOP of 3.3 suggesting that it could be a better system to implement in terms of the metrics stated. It has the highest overall cost of $3,000,000 for CAPEX & OPEX The next is the TUAV system with a score MOP of 3.0 and the last is the Fixed Wing UAV with score MOP of 2.3. this shows that the TUAV system is a good point in between the two other proposed systems, and it has the lowest overall cost of $145,000. SATCOM has the lower reliability score because overall it is maintained 60 times over 5 years however the TUAV and FW-UAV are maintained 180 times over 5 years. However, the cost of maintaining the SATCOM is approximately 10 times more than the costs for the TUAV and FW-UAV.