Drone -Based Solution for Efficient Search and Rescue Mission

“It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.”

—Dr. Robert H. Goddard

Table of contents

01 About Us

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02 Introduction

University of Antioquia

Central Campus (Medellín)

Eastern Campus(Carmen de Viboral)

Model-Based Systems Engineering (MBSE) Course

Some projects…

Design and Validation of a Stratospheric Vehicle Using Model -Based Systems Engineering (MBSE)

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Development of a High - Power Rocket Model using the Arcadia Method

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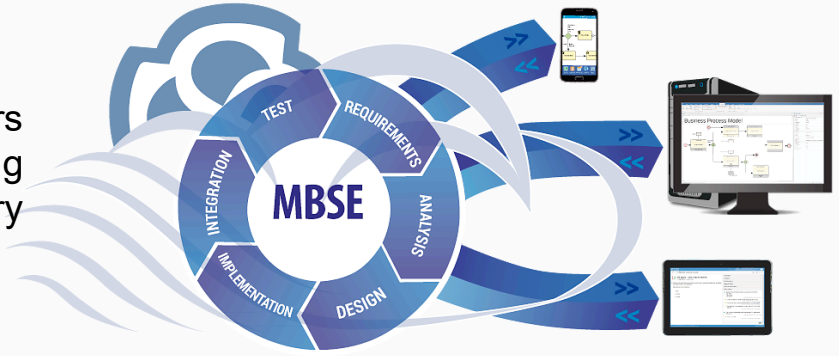
Design and Validation of a Stratospheric Vehicle Using Model -Based Systems Engineering (MBSE)

Mercury is the closest planet to the Sun and the smallest of them all

Why Choose MBSE and Capella?

Model-Based Systems Engineering (MBSE) offers a modern, structured approach to designing complex systems, using models as the primary means of communication and documentation.



Capella

Open Source MBSE Solution

Capella, as an MBSE tool, provides an intuitive platform that supports the Arcadia method (Architecture Analysis and Design Integrated Approach) .

03 Problem context

Challenges in Search and Rescue Missions

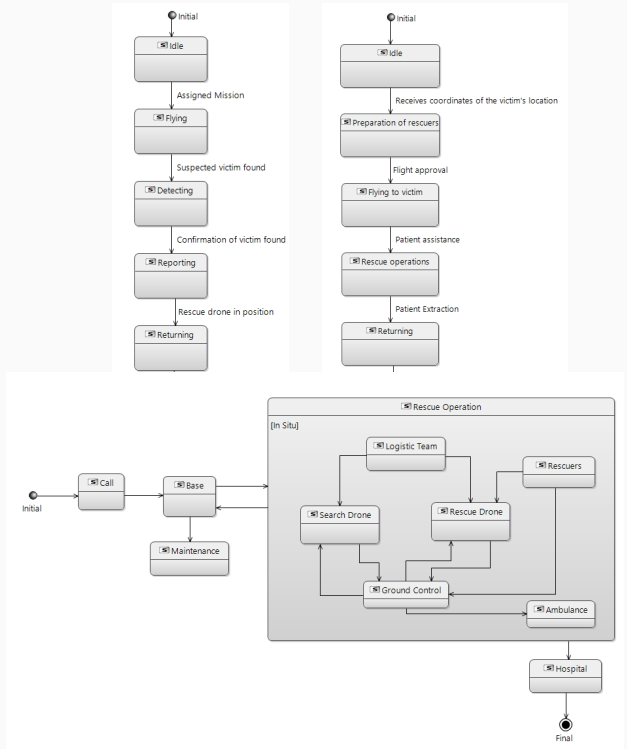
- Victims are often stranded in remote, inaccessible areas or hazardous environments.
- Traditional methods rely heavily on ground teams, which are slow and face significant risks.

How Search and Rescue Missions Are Conducted

Our Vision for Search and Rescue Missions

For our proposal, we divide each operation into two crucial phases, ensuring its effective development : the search phase and the rescue phase .

The search phase focuses on quickly and accurately locating people in difficult conditions, while the rescue phase concentrates on safe and efficient extraction .



Key Definitions for Understanding

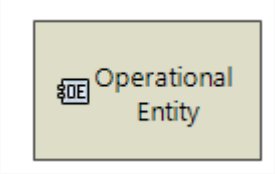
Victim : Refers to a person who has suffered harm, damage, or an adverse situation due to a circumstance, such as an accident, disaster, or any unexpected or harmful event.

Patient : Refers to any victim who has had direct contact with rescuers; in other words, a victim becomes a patient once they are in the care of the rescuers.

Checkpoint : Refers to a control point or a strategically selected location near the area, used to ensure the progress or status of the operation .

04 Operational Overview

Entities and Actors



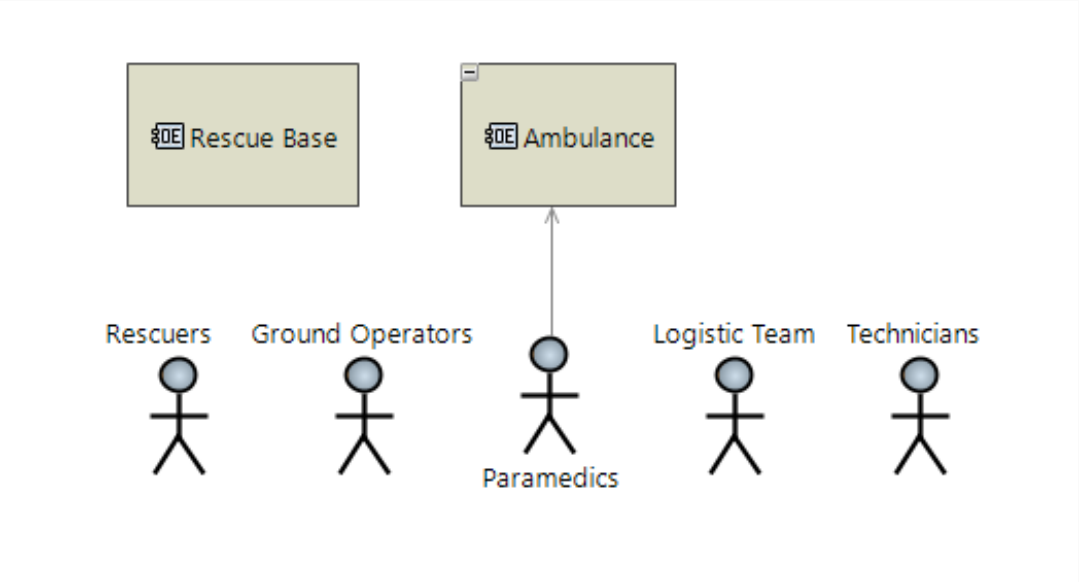
Operational Entity : A real-world entity (such as an organization or system) that interacts with the system being studied or with its users.

Operational Actor : A human, indivisible entity within an Operational Entity who has a specific role in the operation (e.g., a pilot or an operator) .

Entities and Actors

For our case:

- Five Operational Actors
- Two Operational Entities



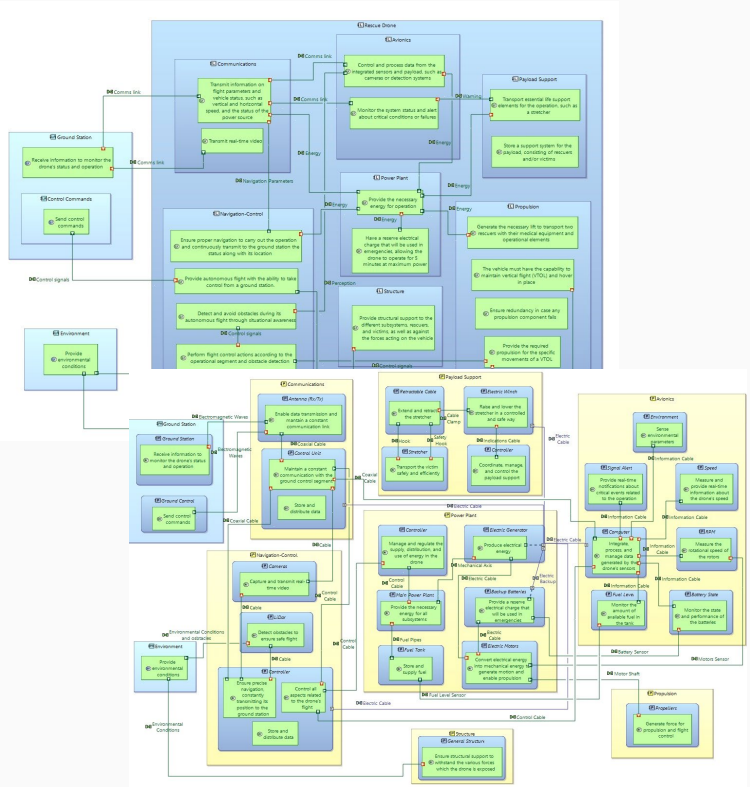
Search and Rescue Systems

Search System: The search system uses drones to locate victims in hard-to-reach areas. After taking off from a control station, the drones fly to the search area, descend to a set altitude, and follow specific search patterns. Upon locating a victim, the drone sends the location to the control station for a quick and efficient response.

Recommendation: DJI Matrice 300 RTK

Search and Rescue Systems

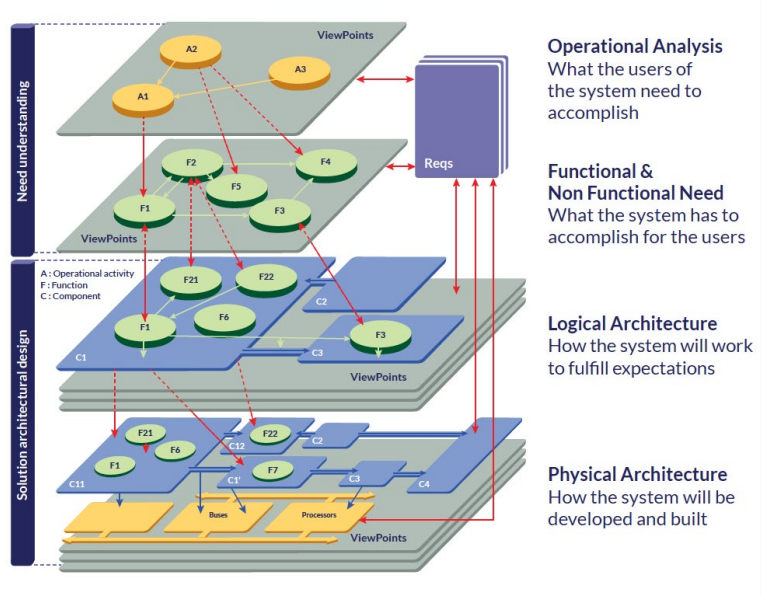
Rescue System : The rescue system is responsible for extracting the victim once located . This system consists of a main drone capable of carrying its own weight, as well as that of two equipped rescuers and a first aid kit . The drone has the ability to avoid obstacles and maintain stability in static flight, which is crucial for allowing the rescuers to prepare for the victim's extraction .



05 MBSE implementation

Arcadia Method

- Understand the real needs of the context .
- Define the architecture considering engineering as a whole .
- Facilitate validation and verification .
- Support requirements gathering



Capella MBSE Tool - Arcadia

Operational Analysis

Rescuers: Access and extract the victims

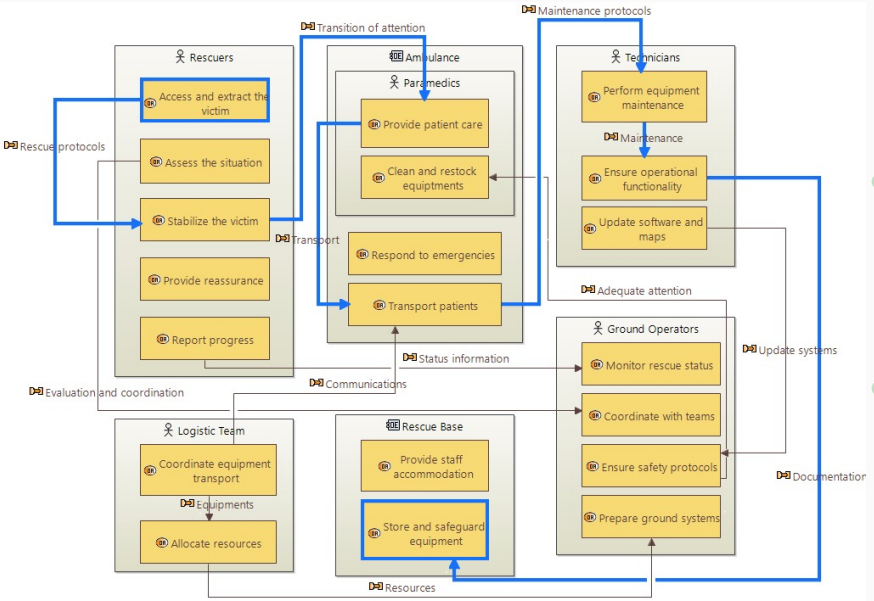
Ambulance -Paramedics : Provide medical care and transport the victims to safe facilities.

Technicians : Keep the equipment operational.

Ground Operators : Monitor the status of rescue operations.

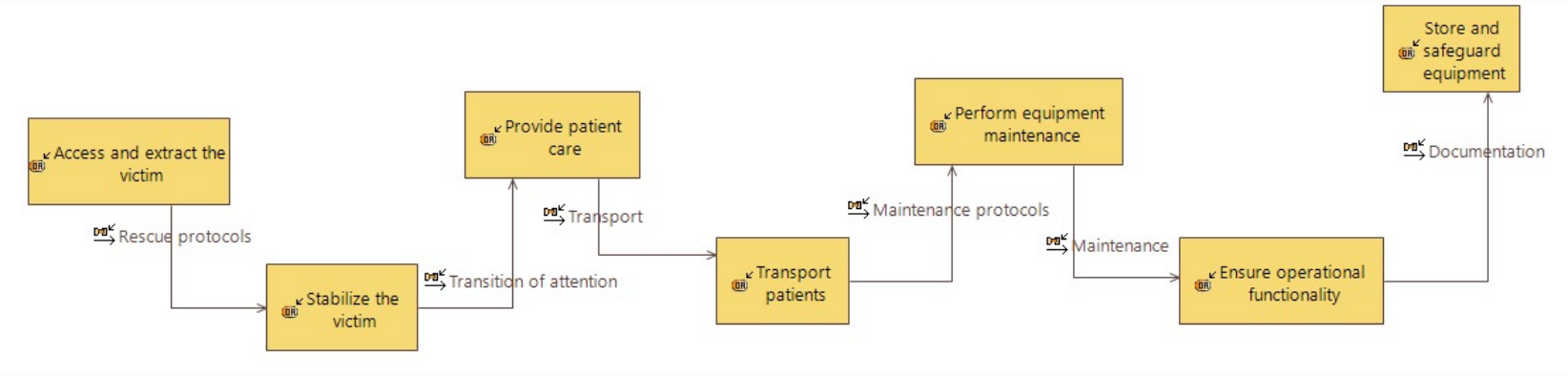
Logistic Team: Manage the transportation of equipment.

Rescue Base: Provide accommodation for personnel.



Operational Architecture Diagram OAB

Operational Analysis



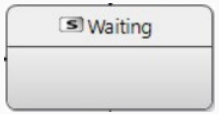
Rescue Operational Process

Operational Analysis

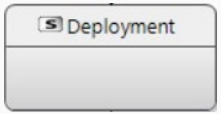
Mode and State Machine :

- Clarity in the system's behavior
- Early error identification
- Coordination between subsystems
- Support for testing and simulations

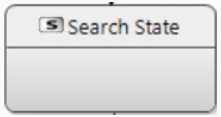
Operational Analysis



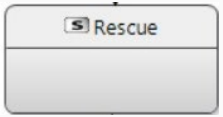
System ready, awaiting activation



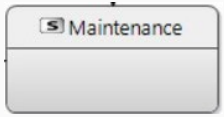
The resources are deployed



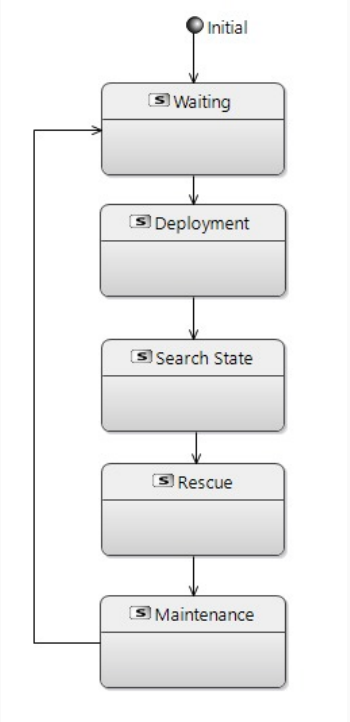
Victim location



Extraction and victim stabilization operation



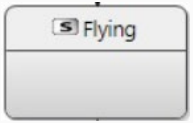
Ensuring equipment readiness for future missions



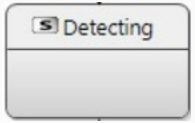
Global MSM

Operational Analysis

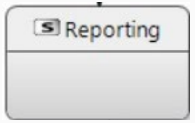
Drone at rest, awaiting mission assignment.



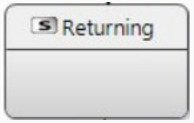
The drone is deployed and flies to the assigned area.



The drone uses its sensors to search for a potential victim



The drone sends a detailed report to the rescue team

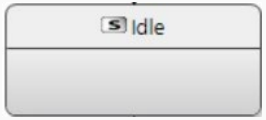


The drone returns to its point of origin

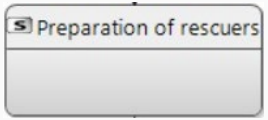
The system completes the operation

Search MSM

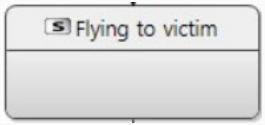
Operational Analysis



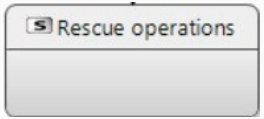
Drone idle, awaiting victim's location



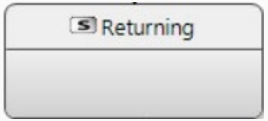
Rescuers prepare with the necessary equipment



The drone is deployed and flies to the location provided by the search drones.

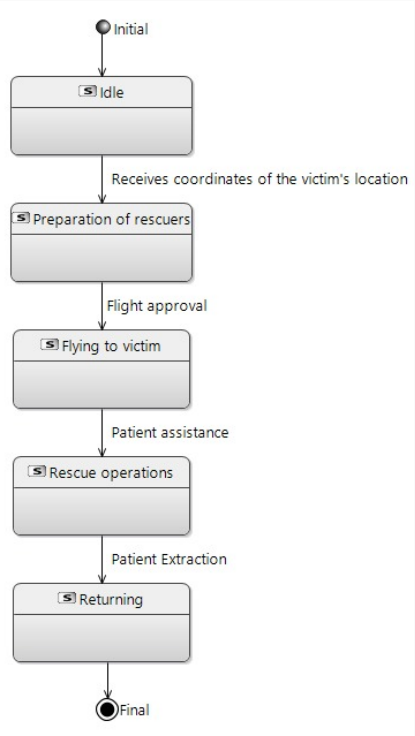


Rescuers apply techniques for quick and safe patient extraction



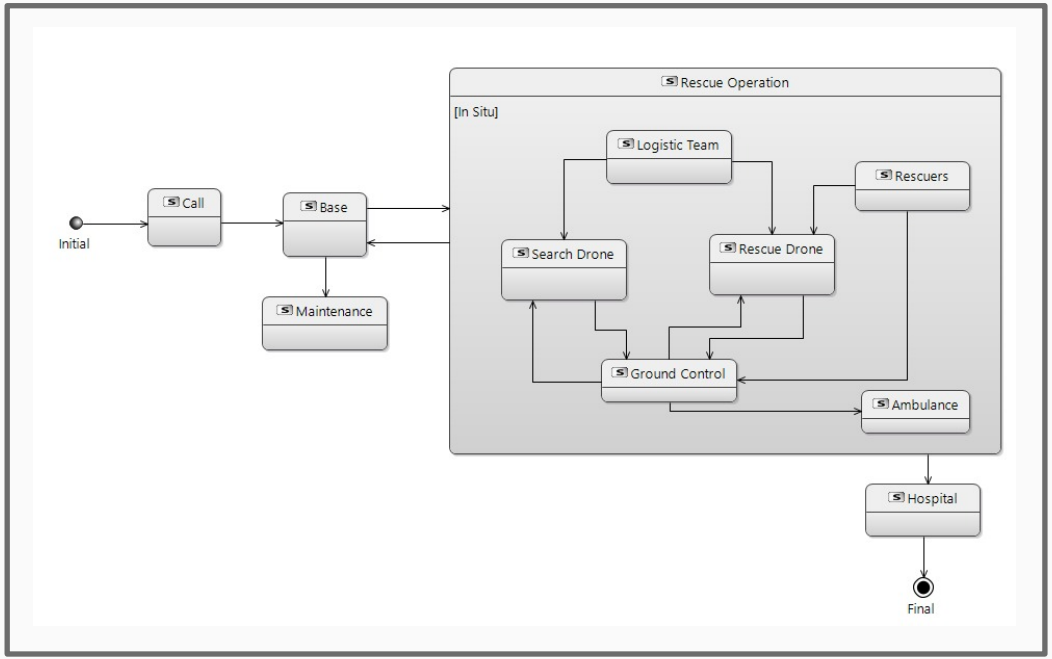
The drone returns with the patient to base for handover to paramedics

The system completes the operation



Rescue MSM

Operational Analysis

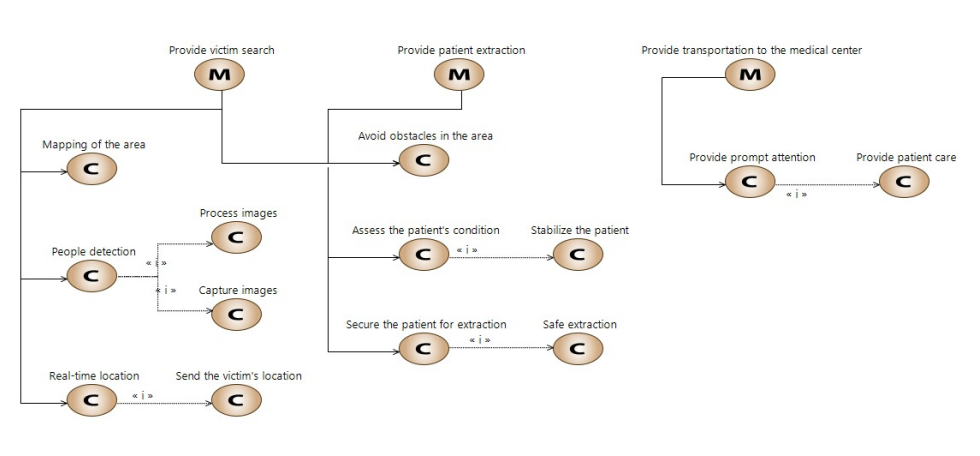


MSM Coordination

System Analysis

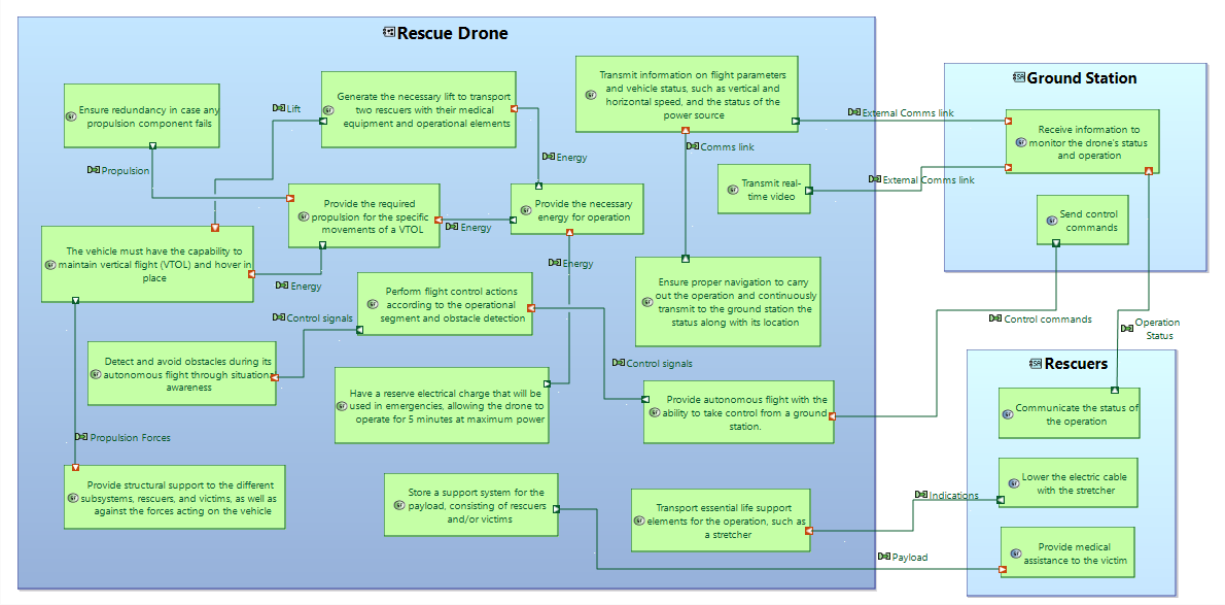
Main Missions :

- Provide victim search
- Provide patient extraction
- Provide transportation to the medical center



Mission Capabilities Blank
MCB

System Analysis

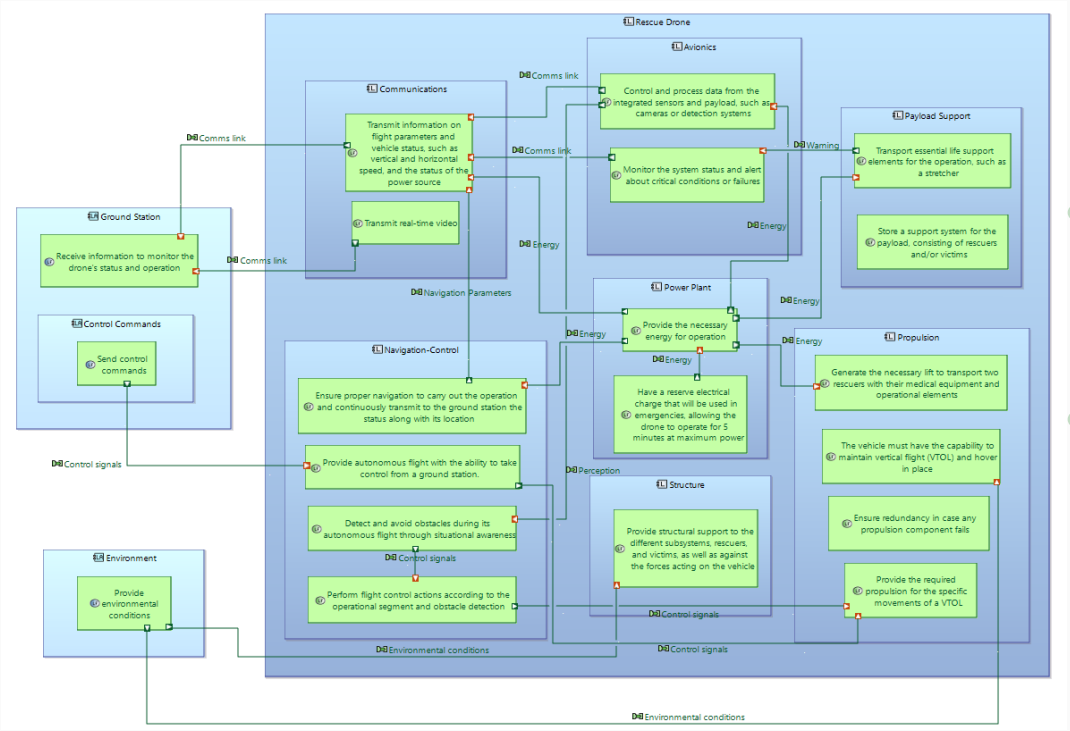


System Architecture Diagram
SAB

Logical Architecture

Subsystems :

- Communications
- Navigation – Control
- Avionics
- Power Plant
- Propulsion
- Payload Support
- Structure

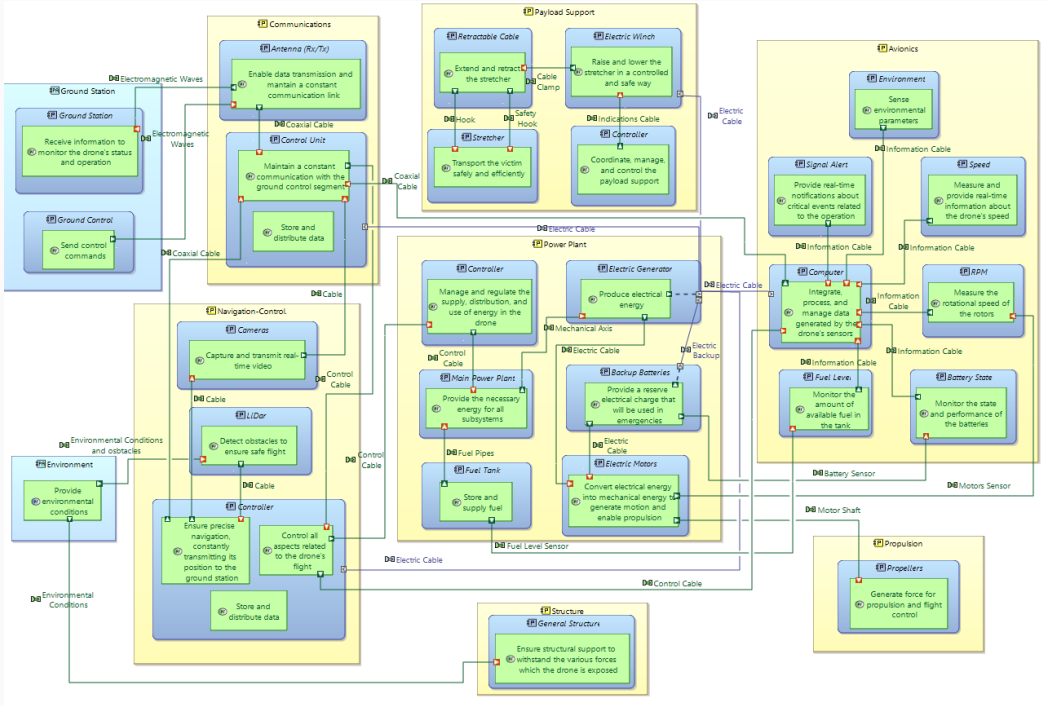


Logical Architecture Diagram LAB

Physical Architecture

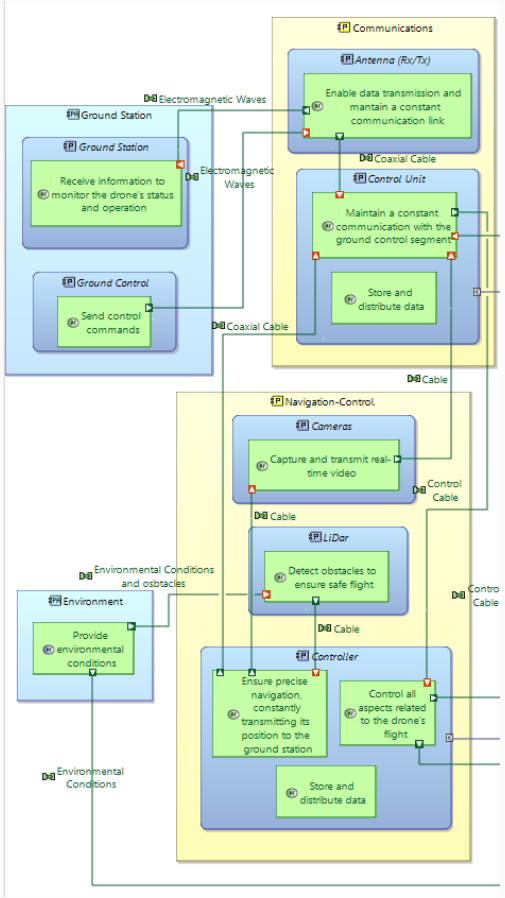
Advantages :

- Identify the necessary physical components for the drone.
- Relate each component to its function within the system.
- Understand the interactions between the different subsystems.



Physical Architecture Blank PAB

Physical Architecture



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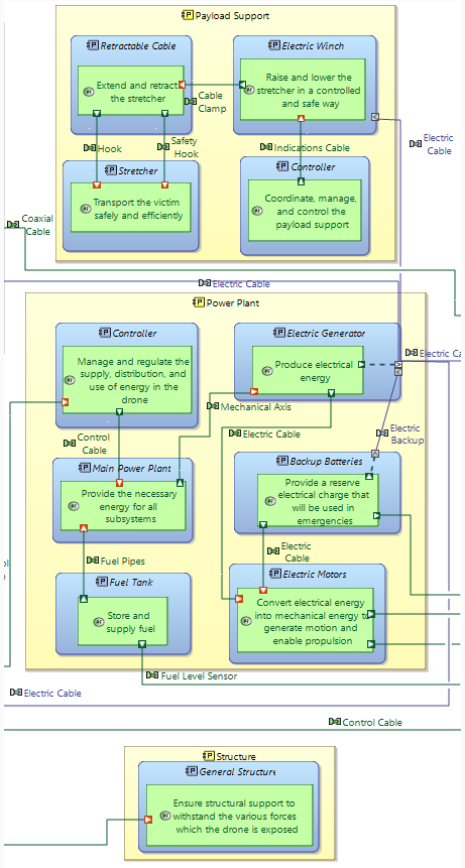
Physical Architecture



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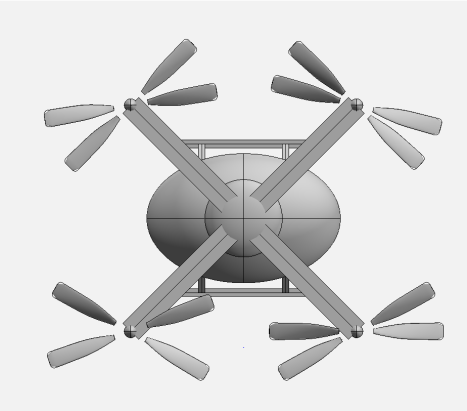
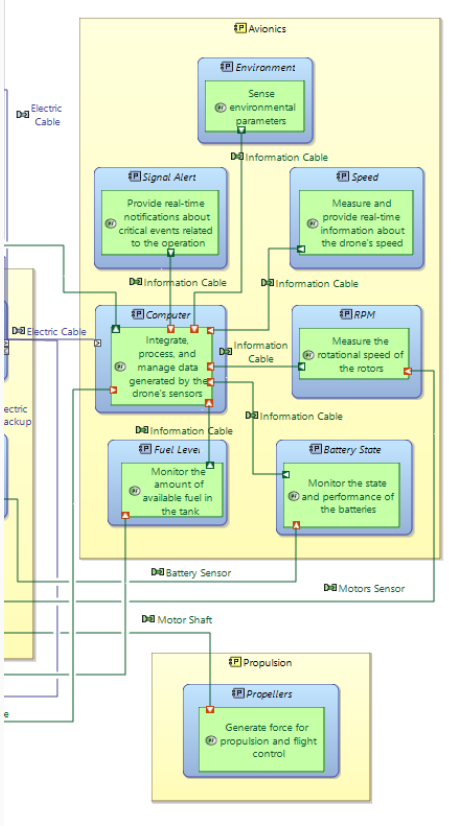
Physical Architecture



OpenVSP Model



Physical Architecture Blank PAB

06 Conclusions and future work

Conclusions

- The use of MBSE enabled the efficient structuring and management of the complexity of the operation and drone design.
- Thanks to Capella, complete traceability was achieved from the initial requirements to the implemented solutions, ensuring that the drone's main functionalities were aligned with operational and rescue needs.
- The model-based approach enabled the development of a modular drone design, where each subsystem can be upgraded or replaced without significantly affecting the rest of the system.
- The current design approach allows for meeting the operational requirements.
- The drone, as an aerial rescue system, successfully fulfills its primary objective: providing a swift and safe solution for the evacuation of injured individuals in hard-to-reach areas, thanks to the precise integration of all its subsystems.

Future Work

- Perform the validation and verification of the system.
- Model operational scenarios to identify potential failures or areas for improvement .
- Design a physical mockup to verify the integration of the main components, without requiring the drone to be fully functional at this stage.

Thanks!

Do you have any questions?

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GitHub Gerarding