

# Planning and Evaluation of UAV Mission Planner for Intralogistics Problems

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## Outline

## 1 Introduction

- Motivation
  - Objectives

## 2 Methodology

- System's Architecture
  - Case Study
  - Mission Planners
  - Optimization Problem Model
  - Planner Evaluation Methodology

### 3 Experimental Evaluation

4 Summary

## Problem

# Delivery of Inputs to Production Lines (Intralogistics)

## Motivation



Figure 1: Robot Arm. Source: The New York Times

## Motivation



Figure 2: Conveyor Belt. Source: iStock

## Motivation

GIF: Use of UAV. Source: Robotic Gizmos

## Motivation



Figure 3: DHL UAV. Source: DHL

## Motivation



Figure 4: Amazon UAV. Source: Amazon

## Motivation



Figure 5: Multirotor UAV. Source: MULTIROTOR

## Motivation

- ▶ Logistics has become a competitive and fundamental factor for organizations, involving the management, conservation, and supervision of freight transport;
- ▶ An excellent logistics means client satisfaction; so speed is still an important factor in a successful logistics process.

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Evaluate UAV intralogistics mission planner algorithms with respect to flight time

- ▶ A novel evaluation methodology for UAV intralogistics mission planners algorithms;
- ▶ Development of an intralogistics mission planner framework;
- ▶ Use of a commercial UAV system in intralogistics missions to demonstrate the evaluation methodology efficiency.

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## System's Architecture

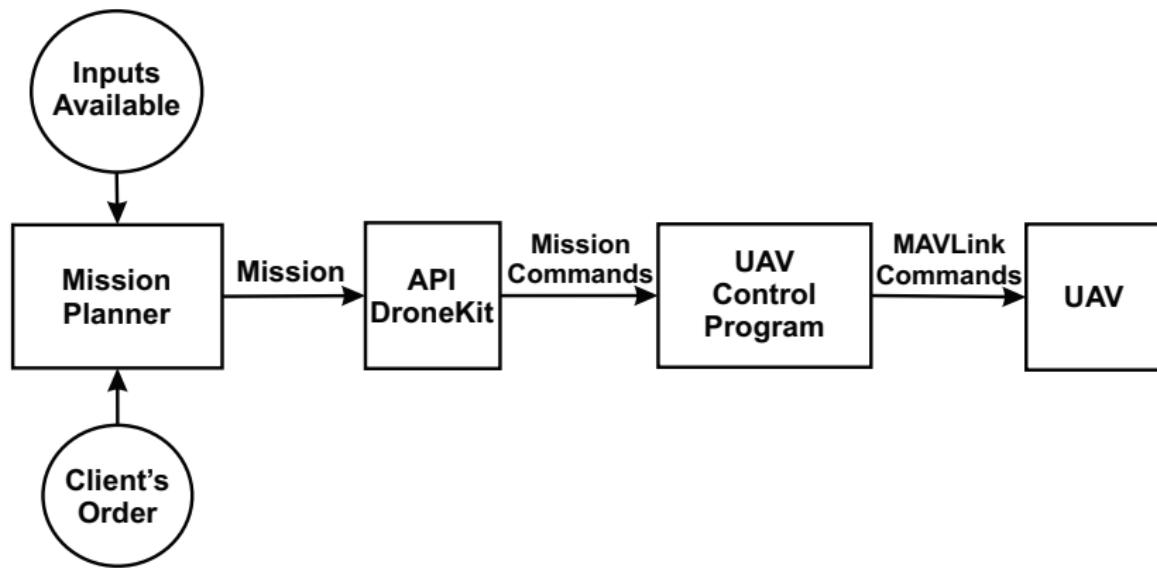


Figure 6: System's Architecture.

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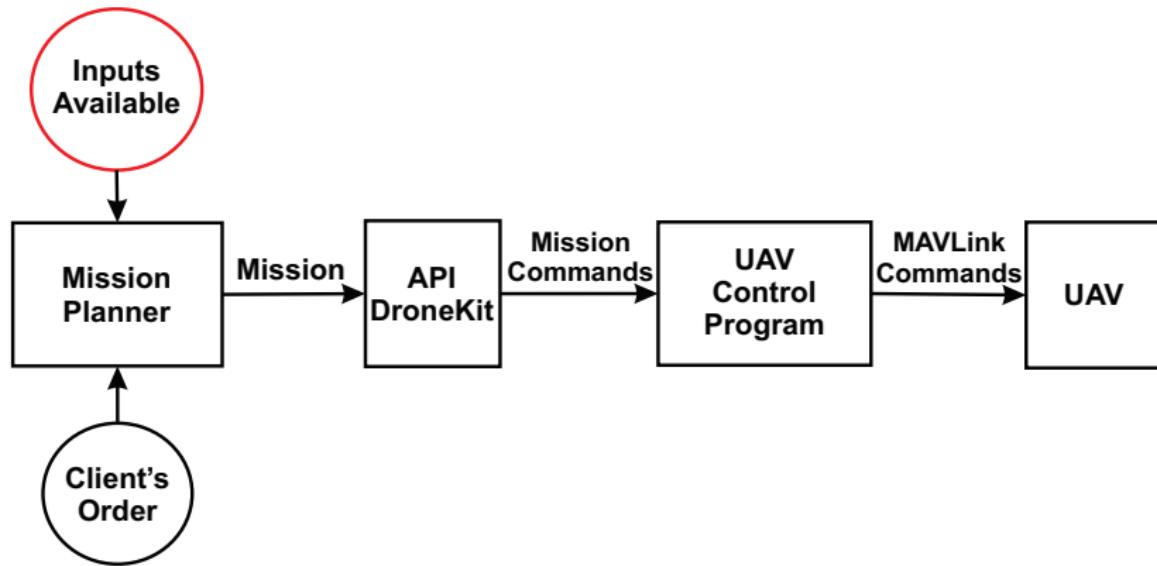


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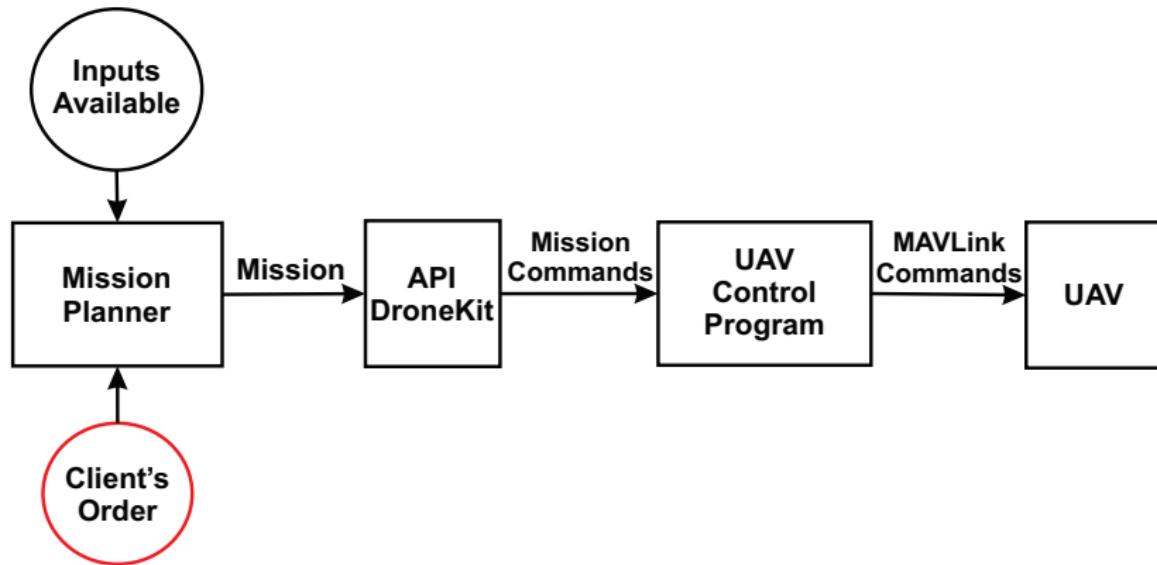


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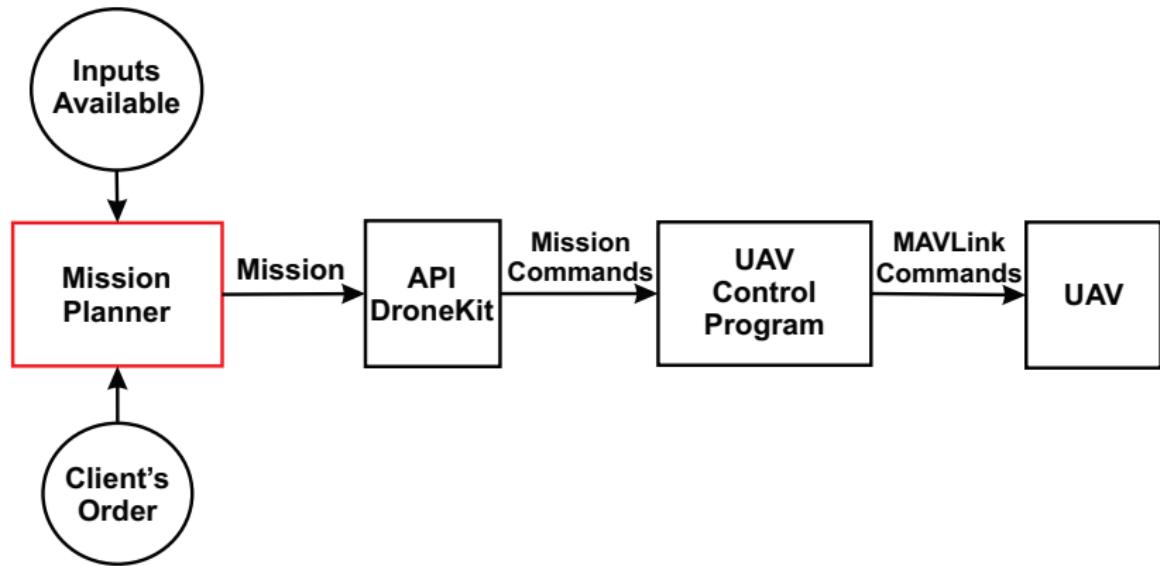


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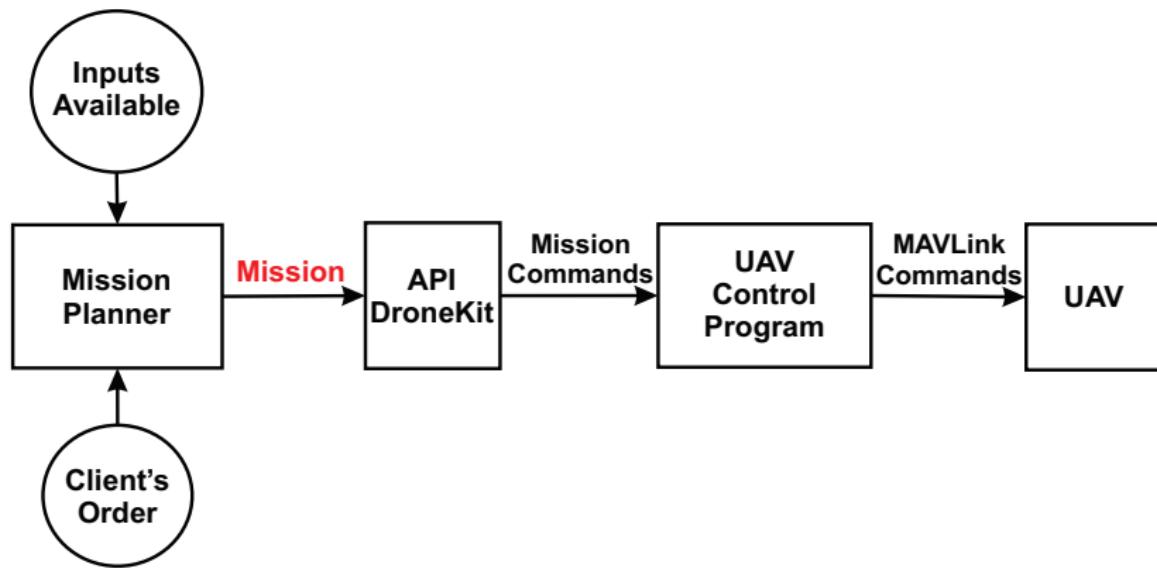


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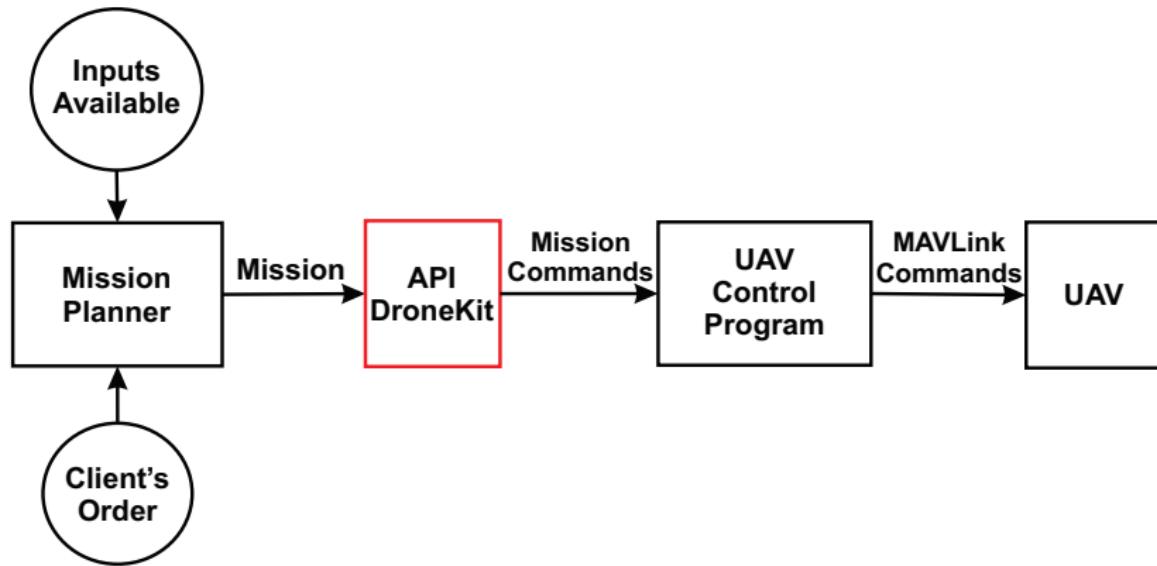


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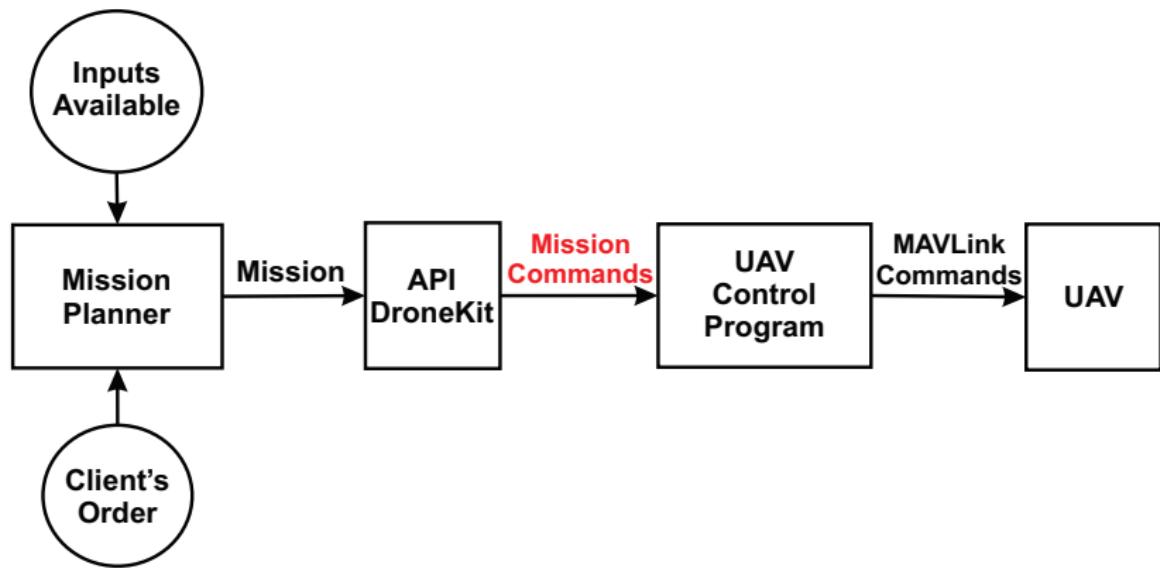


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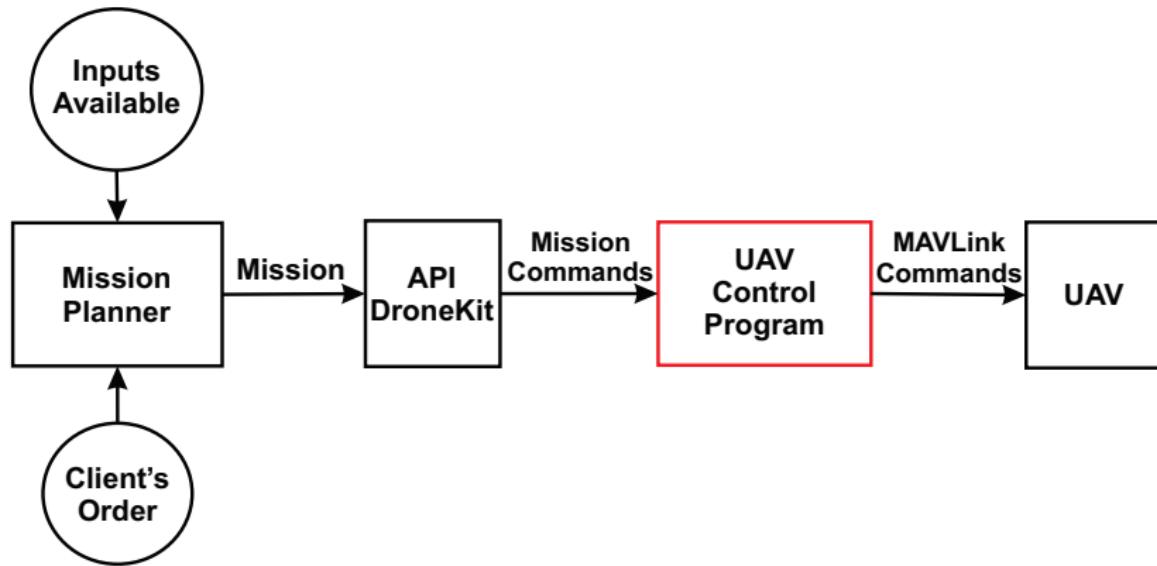


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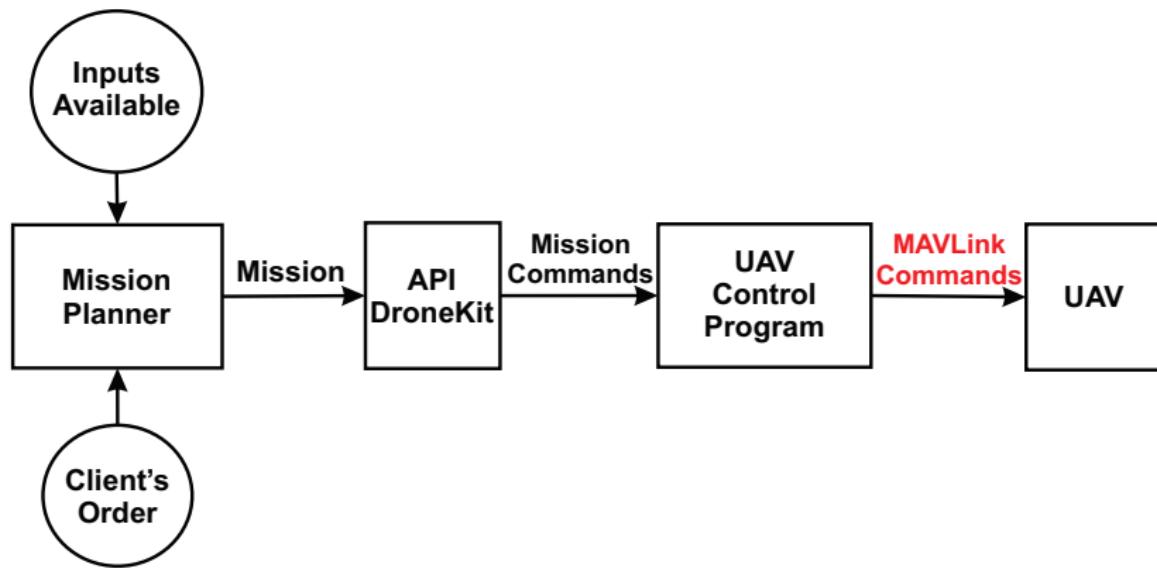


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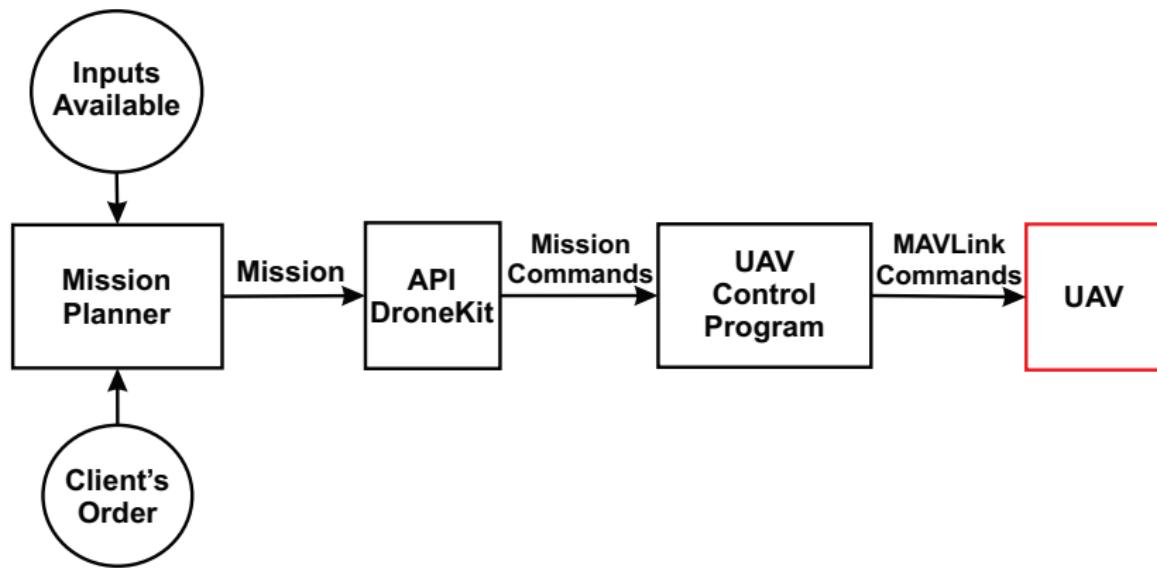


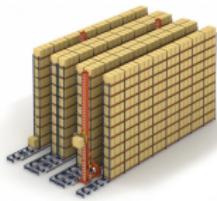
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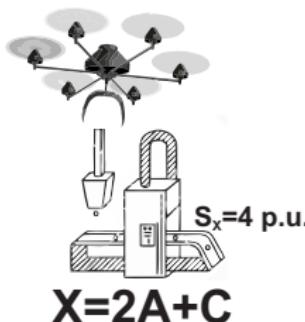
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## Case Study

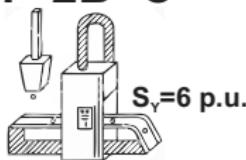
**Warehouse**



**A, B, C**



**Y=2B+C**



**Production Lines**

Figure 7: Case Study Representation.

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# Mission Planners

## Planner 1

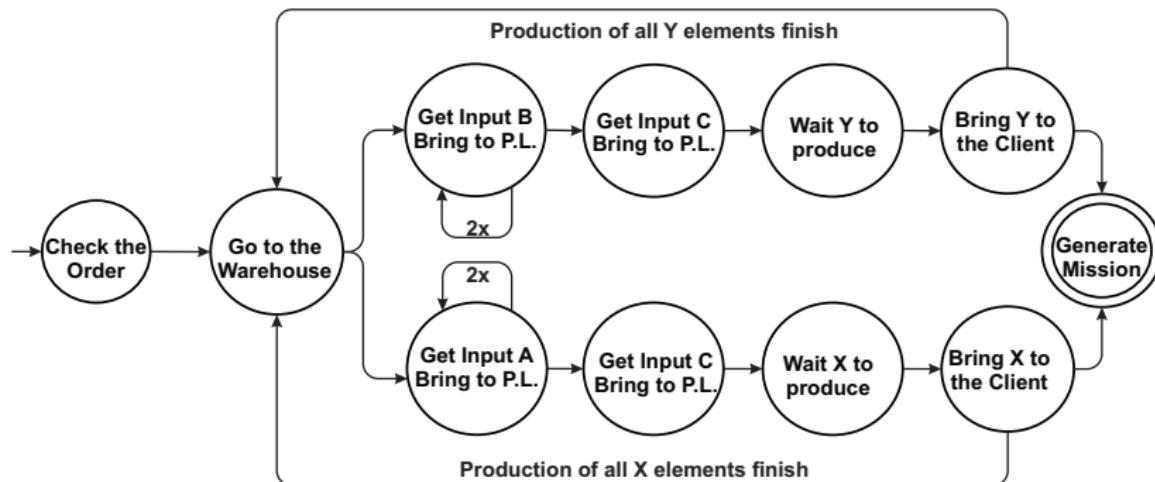


Figure 8: Case Study Representation.

# Mission Planners

## Planner 2

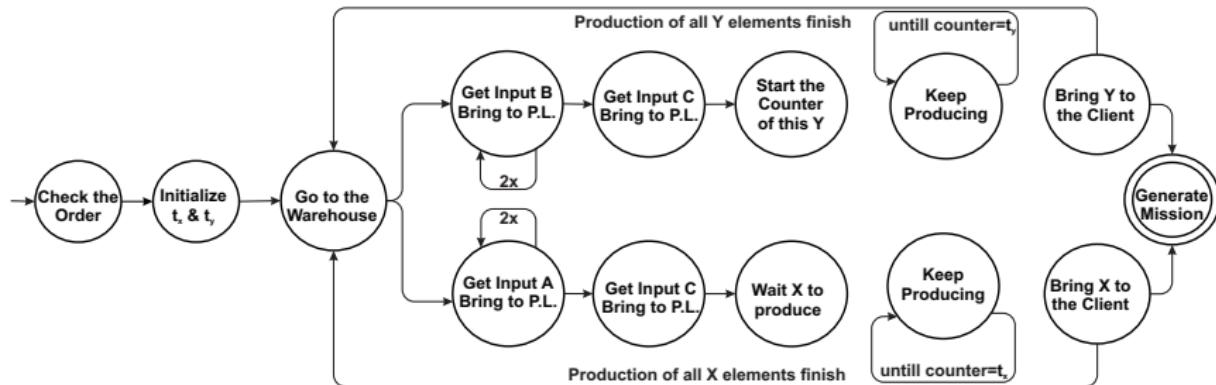


Figure 9: Case Study Representation.

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## Optimization Problem Model

$C_{mission}$  - Variable to be minimized.

$$C_{mission} = \sum_{i=1}^M \sum_{j=1}^N (p_j + s_i) x_{ij}, \quad (1)$$

$C_{max}$  - Maximum production time obtained empirically.

$$\begin{aligned} & \min && C_{mission}, \\ & \text{s.t.} && \sum_{i=1}^M \sum_{j=1}^N x_{ij} = 1, \\ & && C_{mission} \leq C_{max} \end{aligned} \quad (2)$$

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## Planner Evaluation Methodology

$c_o$  - Cost obtained by CPLEX Solver.

$c_x$  - Cost obtained by counting the number of GoTo command during a mission.

$$MPCI_X = \frac{c_o}{c_x}, \quad (3)$$

Where  $0 \leq MPCI_X \leq 1$ .

## Experimental Evaluation

The experimental evaluation aims to answer the following research questions:

- RQ1: Does the framework for mission planning, command and control for intralogistics mission using a UAV produce the expected results?
- RQ2: Is the metrics of mission evaluation efficient?

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## Experimental Evaluation

Test #	Flight Time of Planners			
	Simulator		3DR Iris+	
	1	2	1	2
1	460.41	436.08	455.12	441.72
2	460.69	436.89	456.93	440.18
3	460.08	441.68	457.19	447.51
4	460.72	441.03	460.25	438.19
5	460.23	451.87	459.47	445.85

Table 1: Mission Planners Flight Times.

	Planner 1	Planner 2
MPCI	0.319	0.328

Table 2: MPCI of the Planners.

## Summary

- ▶ We have developed a framework for mission planning and control for intralogistics mission using a commercial UAV;
- ▶ We have used that evaluation methodology to evaluate the performance of two different UAV Mission Planner algorithms.
  
- ▶ Outlook
  - ▶ Improve the optimization problem modeling for better results in cost evaluation;
  - ▶ Perform experiments in a cooperative work environment;
  - ▶ Develop more planner strategies such as an algorithm that produces different types of products simultaneously.

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