# ISDN3002

# TEAM MEC

# PROJECT PROPOSAL

## *Trocomotor* *Follower*


Team Members:

Marius LIN, Yifei (ylinbz@connect.ust.hk )

Eric LIANG, Yuchen (yliangbk@connect.ust.hk )

Cat HUANG, Qiucan (qhuangag@connect.ust.hk )

Supervisor:

Prof. Ravindra Stephen GOONETILLEKE

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

The Division of Integrative Systems and Design (ISD)

# SUMMARY

This is a project proposal document for ISDN 3002 Team MEC. The proposal presents a problem of how might we design equipment for the trolley hauling worker that can improve their working efficiency?

A semi-autonomous trolley hauling robot, Trocomotor Follower which is part of fully autonomous trolley hauling system Trocomotro will be presented in this proposal.

The robot Trocomotor Follower is a robot that can follow the trolley worker's scooter in order to make the workers work more efficiently. Product storyboard and concept sketch will be mentioned in his proposal.

This proposal states that Trocomotor follower is a worth building and feasible product that can be built to fulfil its purpose and solve the problem under this project

The objective of this project should be building a fully functional Trocomotor Follower.

The timeline of the project and the budget (predicted) will be mentioned in this proposal.

# CONTENT

# 1. INTRODUCTION

ISDN 3002 is a project based learning course which goes through the process of product design. Students need to communicate and identify problems for companies.  This proposal focuses on solving the problems for HKIA.

Students should go through the process of design thinking, define problem, redefine problem, divergent thinking, prototype building process and produce a functional product with a live demo at the end of this project.

# 2. PROBLEM STATEMENT

## Background

### Existing problem/ Context

In HKIA and many other airports in the world (except some in North America), trolleys recycling process is mainly done by airport workers or contractors. The purpose of this job is to maintain the environment of the airport and keep enough trolleys at the entrances and baggage reclaiming points. However this job is also highly repetitive and labor costly ,so more work can be done to improve the efficiency of this process. Base on our understanding and observation in HKIA, we found some of the pain points/ existing problem listed below:

1.Labour intense

Around 13,000 baggage trolleys are distributed throughout the HKIA to service its enormous passenger flow. One of the main pain points is that recently there are not enough workers to fulfill this amount of trolley recycle task.It is also hard to find new workers , because few people are willing to do this job.

2.Efficiency

During one recycle process workers need to frequently travel between many security points and entrances to ensure that every trolley station has an equal amount of trolley.This process is highly repetitive and time costly, as workers need to frequently spend time on the road and stop at each trolley recycle/parking point.

3.Division of labor

During the process, one worker needs to take care of gathering trolleys , driving to a parking point and stopping the vehicle to push part of trolleys into the parking line, then get on the vehicle and head to the next point. This requires a lot of getting on/off vehicle movement and the trolley carrier vehicle spends lots of time waiting for workers to park the trolley before getting going again. The delivery ability of trolley carrier vehicles is not fully used.

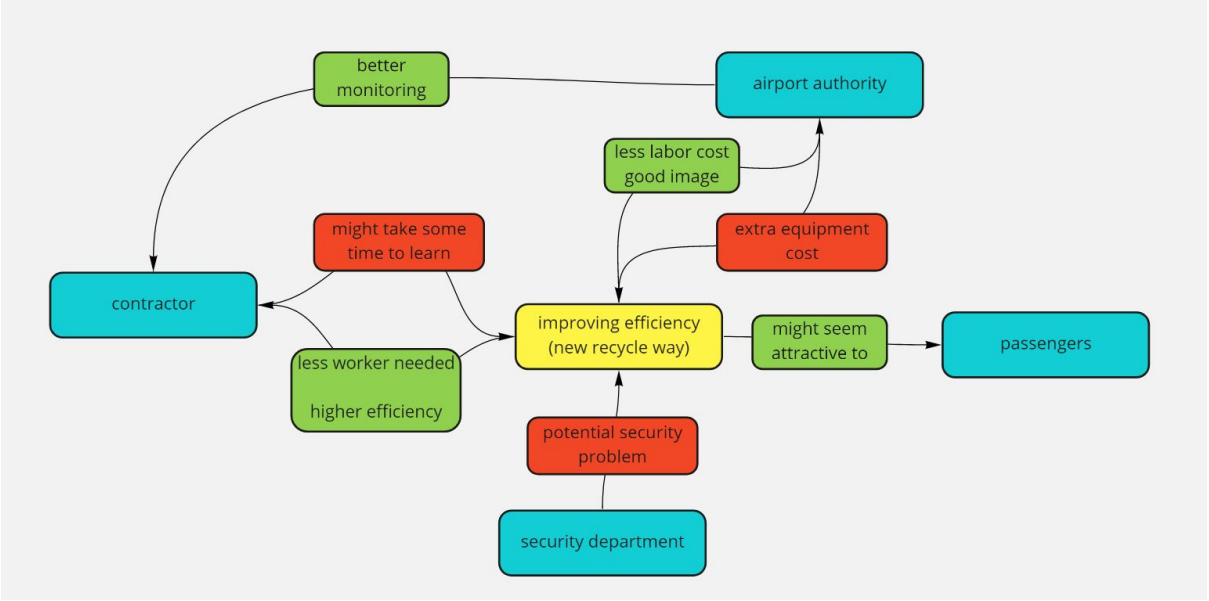
## Interview

Below is our interview to some of the airports related workers about the airport trolley recycle process which further verify our observation:


## Refined problem

How might we design equipment for the trolley hauling worker that can improve their working efficiency.

# Stakeholder Analysis



# 3. PROPOSED SOLUTION

To solve the problem mentioned in the previous session, we propose a new working procedure to cooperate with a robot which will be explained in the following session.

## Product Concept

### Brand / System: Trocomotor

Trocomotor is a system beyond this proposal. Trocomotor is a grand blueprint for a full autonomous trolley hauling system which involves several subsystems including long-distance trolley transfer robot, scattered trolleys collecting robot,Locomotive Robot, Follower robot and so on. This document wants the readers to understand the limitations of this semester-long project which only allows the team to finish a very small fraction of it which will be explained in the following paragraph.

### Workers

To explain what role workers play in this system, one needs to know what workers need to accomplish currently in the airport. The trolley hauling workers are responsible for the following things:

1. Collect all the scattered trolleys to a train
2. Connect them to the scooter they have now.
3. Drive the scooter and drag the trolley train from the starting point to dropping point.
4. Unload the trolley and order it at the dropping point
5. Repeat 3 & 4 until all the trolleys are set up.
6. Go back to the starting point and start again.

The proposal wants to make the workers more efficient by cutting off the time they needed for process 3 & 4. This proposal focuses on reducing the frequency of workers travelling between starting point and dropping point by increasing the trolley they can transfer each time. By using the following robot, this can be achieved.

## Robot: Trocomotor Follower

Trocomotor Follower (T-Follower in the following text) is a robot with the following ability. In this project and proposal content, T-Follower should be following the scooter or the train of trolleys driven by the workers.  T-Follower should be capable of dragging a sizable amount of trolley and follow the train of trolley driven by the workers.

T-Follower consists of a chassis subsystem, a vision sensing subsystem, a control subsystem and a warning system. The chassis system allows the T-Follower to move with high flexibility and grip the head of the trolley train firmly. The vision sensing subsystem acts as the eye of the robot which will be responsible for detecting the key feature to perform the following motion. The control system will be controlling the robot. And, the warning system will be keeping the pedestrian away from a working T-Follower so that it will meet the safety manner of the airport.

# Storyboard

The storyboard illustrates the working procedure of the Trocomotor Follower.

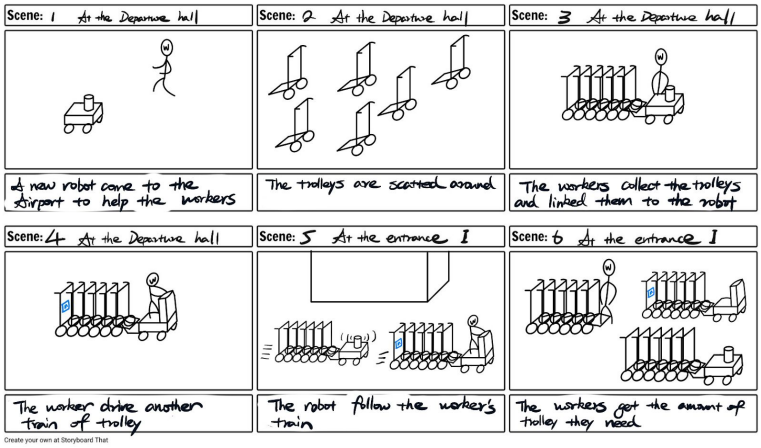



Figure 1-1: Storyboard 1

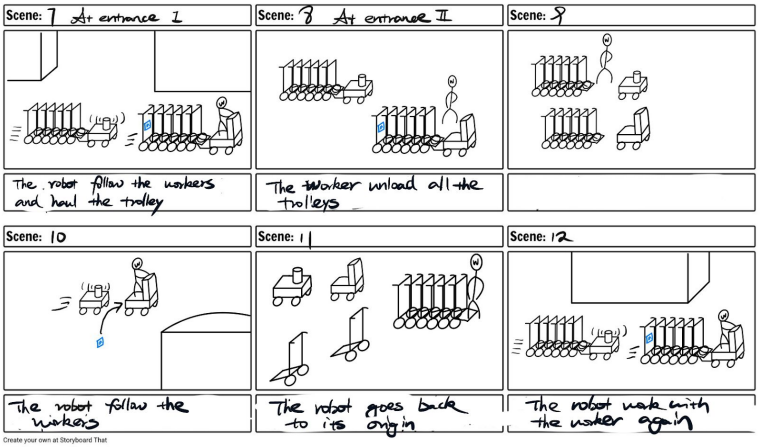



Figure 1-2: Storyboard 2

Scene 01: This scene shows the two important elements of this system, the Trocomotor Follower and the workers.

Scene 02: The trolleys are scattered around, waiting for collection.

Scene 03: The workers finish collecting the scattered trolleys and linked them to T-Follower.

Scene 04: The workers drive the scooter hauling a train of trolleys.

Scene 05: T-Follower follows the worker's scooter

Scene 06: The works arrive at a dropping point and place some of the trolleys.

Scene 07: The worker drives the scooter to the next stop and the T-Follower follows.

Scene 08: The works arrive at another dropping point and place some of the trolleys.

Scene 09: The trolleys are all placed after this dropping point.

Scene 10: The worker drives the scooter and T-Follower follows.

Scene 11: The worker and T-Follower arrive at the starting point.

Scene 12: Start another round of working.

## Concept Sketch

Figure 2 demonstrates our project sketch.

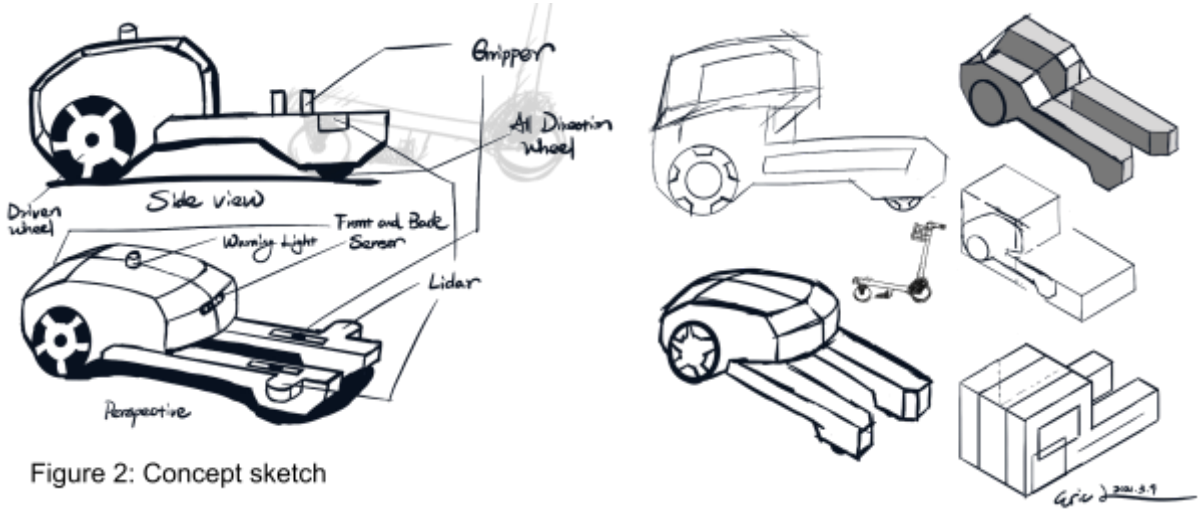
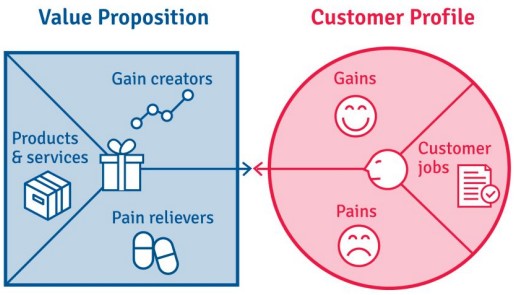



Figure 2: Concept sketch

## Value Proposition




At present, as mentioned by HKIA, the problem of labour intensive still exists. We know that the airport has a lack of workers and want robots or other processes to replace the workers. We realize that the current set up of workers and processes can be improved by making the workers more efficient at working. We also realized that as the facade of HK, HKIA wants to make the airport more autonomous in order to give travellers a good impression. Our proposal of Trocomotor would like to meet all the needs above for HKIA but under this project we want to start with Trocomotor Follower in order to test out and set up the direction for the whole system in the near future.

# 4. FEASIBILITY ANALYSIS

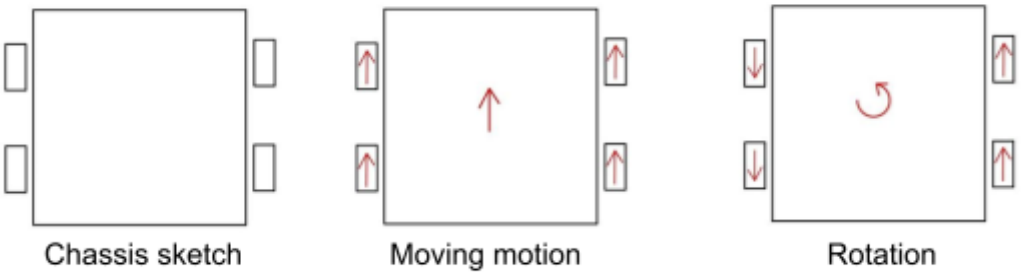
Feasibility is one of the most important factors of a project. In order to execute this project well, a feasibility analysis is necessary. The feasibility analysis section will only focus on T-Follower, because of limitations of resources, such as the time limitation. This section will discuss the feasibility of T-Follower in the following sequence the technical feasibility, potential obstacles, and key personnel.

## Technology Feasibility

The T-Follower robot proposed by this proposal has four subsystems, chassis subsystem, control subsystem, vision subsystem. This section will discuss the technology feasibility of different subsystems.

### Chassis Subsystem

The chassis system contains all structures that sustain the whole robot and all the components that drive the whole robot. We would like to propose a square structure with four driving wheels chassis in this proposal. Carrying the robot itself and dragging the trolleys are the most important tasks for the chassis, which means the chassis must be feasible for moving and rotating in a flat plane. The feasibilities of moving and rotating are shown in the following figure.



## Control Subsystem

The control subsystem contains all the devices that execute the low-level commands, such as the motor control commands and necessary connections including power connections and signal connections between these devices. In the final product, a STM32 based control board is proposed. Due to the resources limitation, a STM32 based development board will be used to replace the final control board in this semester.

CAN(Controller Area Network) bus will be used in the control system to ensure the robustness of communication among critical components. The high-level commands will be sent via USART(Universal Synchronous/Asynchronous Receiver/Transmitter). To make sure the correctness of communication, a private protocol which embedded CRC32(32 bits cyclic redundancy check) code for verification, will be used.

All the technologies mentioned above are mature solutions, the proof of feasibility is omitted in this proposal, since many tests and verification have been done many times.

## Vision Subsystem

Vision subsystem takes responsibility of sensing the environment and generating high-level commands which will be decoded and executed by the robot. The vision subsystem consists of a camera module and a mini PC.

Vision sensing will be implemented above OpenCV, an open source code computer vision system. The main task of vision sensing is detecting the pattern of target in real time and calculating the relative position between robot and target. In consideration of the complexity of the environment in the airport, we propose a mix type marker. The mark is equipped with LED (Light-emitting diode). The LED is a distinct pattern for the vision system to locate. Usage of LED accelerates the detection of the vision system, but brings in the possibility of wrong detection when it encounters reflective surfaces. A pattern is added to the marker near the LED to solve this problem. The vision system will match the pattern to identify if the marker is the correct one to track.

The key algorithms needed in the vision system including, classification, pnp solving and pattern matching. All of them are implemented in OpenCV. For our specific needs modification of original generic source code is required.

## Potential Obstacles

This section will discuss the potential obstacles that may occur at the development period. Even though this document tries to list all potential obstacles, many accidents may happen. To avoid the side effects of accidents, more resources are needed.

1. Logistics

   Due to the current situation, transportation may spend too much time.

2. Control model

   According to the current proposal, the control model of the robot is simplified. It may be invalid in the actual scene.

3. Mismatch between lab environment and real environment.

   The testing environment and real environment are different and may cause some problems, such as failure of visual detection due to change of light conditions.

## Key Personnel

| | |
|---|---|
| Marius (LIN, Yifei) | Embedded system and software engineering |
| Eric (LIANG, Yuchen) | Mechanical design and manufacture |
| Cat (HUANG, Qiucan) | Embedded system and software engineering |

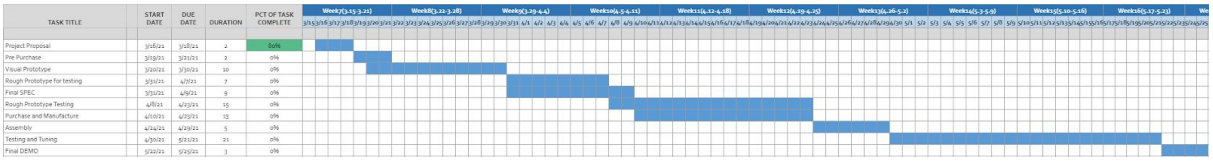
# 5. OBJECTIVES

The objective of this project will be presenting a functional T-Follower on Demo day which can perform the following function at an acceptable speed behind a moving trolley while hauling a sizable amount of trolleys.

# 6. TIMELINE

| TASK TITLE | START DATE | DUE DATE | DURATION |
|---|---|---|---|
| | | | |
| Project Proposal | 3/16/21 | 3/18/21 | 2 |
| Pre Purchase | 3/19/21 | 3/21/21 | 2 |
| Visual Prototype | 3/20/21 | 3/30/21 | 10 |
| Rough Prototype for testing | 3/31/21 | 4/7/21 | 7 |
| Final SPEC | 3/31/21 | 4/9/21 | 9 |
| Rough Prototype Testing | 4/8/21 | 4/23/21 | 15 |
| Purchase and Manufacture | 4/10/21 | 4/23/21 | 13 |
| Assembly | 4/24/21 | 4/29/21 | 5 |
| Testing and Tuning | 4/30/21 | 5/21/21 | 21 |
| Final DEMO | 5/22/21 | 5/25/21 | 3 |

## Gannt Chart



https://docs.google.com/spreadsheets/d/1bOhJ7lHA0vilDr3jceyJUyf2_KnEwY521k9hsB6Qjp0/edit?usp=sharing

# 7. BUDGET

| Name | Amount | Unit prize (RMB) | Cost (RMB) |
|---|---|---|---|
| M3508 Motor + ESC | 5 | 899 | 4495 |
| Mainboard | 1 | 239 | 239 |
| CNC Manufacture | / | 3000 | 3000 |
| FLIR Camera | 1 | 1000 | 1370 |
| Other matrials | / | 1000 | 1000 |
| MiniPC | 1 | 5500 | 5500 |
| Chess board | 1 | 600 | 600 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | SUM (HKD) | 19345 |

The budget of this project does not represent the cost of the robot. The team is confident the cost of the robot can be cut down and below to a month salary of a worker which is 13000 HKD.