

# THE DEVELOPMENT OF REMOTE-CONTROL AIRCRAFT TUG (RCAT) FOR LIGHT AIRCRAFT TOWING AT POLITEKNIK BANTING SELANGOR

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**ABSTRACT** – The Remote Control Aircraft Tug (RCAT) project endeavors to revolutionize aircraft handling within airport and hangar settings, aiming to provide a dependable and efficient system for maneuvering aircraft. Utilizing cutting-edge wireless control technology, the project offers precise control over speed and direction, ensuring safe and effective aircraft operation. Key to its operation is the integration of the Arduino microcontroller board and the BTS7960 motor driver, with the Arduino Uno R3 serving as the central control hub. Through sophisticated programming logic, the RCAT can accurately interpret commands from the remote-control system, facilitating seamless execution of desired movements. The adoption of the FlySky FS-i6X remote control system further enhances reliability and range, empowering operators with flexible and intuitive control capabilities. Additionally, the RCAT incorporates a robust locking device structure, constructed from mild steel and a locking pin, to ensure a secure connection between the tug and the aircraft, thereby minimizing the risk of accidental disconnection and safeguarding the aircraft's landing gear during towing operations. Overall, the RCAT project presents a comprehensive solution, combining advanced wireless control technology, state-of-the-art remote-control systems, and innovative hardware and programming, poised to optimize aircraft handling processes and potentially elevate efficiency and safety standards in both approved maintenance training organizations governed by Part 147 regulations and flying academies.

**KEYWORDS** : Aircraft Handling, Remote Control Technology, Wireless Control System, Arduino Microcontroller, Safety and Efficiency

## 1.0 INTRODUCTION

Aircraft ground handling, particularly towing, constitutes a critical operational phase within airport environments, facilitating essential manoeuvres such as pushback, taxiing, and hangar positioning [1], [2]. The execution of these tasks traditionally relies on specialized ground vehicles designed to manoeuvre the aircraft by interfacing directly with its nose landing gear [4], [5]. Historically, conventional towing apparatuses have employed mechanical tow-bars [2], [3], whereas contemporary towbarless configurations utilize hydraulic mechanisms to lift the nose gear wheels. While both methodologies are functionally viable, conventional towing via tow-bars introduces significant operational challenges, most notably the restriction of manoeuvrability within confined architectural spaces such as maintenance hangars. Furthermore, while ground handling incidents are statistically infrequent, mechanical failures or operational misjudgements during towing can precipitate severe consequences, escalating from minor structural damage to catastrophic accidents [6]. Recent high-profile occurrences, including the crushing of a tow tractor at Bangkok's Don Mueang International Airport and the structural damage inflicted upon a Vistara aircraft at Mumbai International Airport, emphatically underscore the critical safety vulnerabilities present in current towing practices and highlight the urgent necessity for innovative, risk-mitigating solutions [7].

To address these prevailing limitations, this research presents the design and implementation of a Remote-Control Aircraft Tug (RCAT), a revolutionary approach aimed at enhancing safety, efficiency, and operational effectiveness. The primary aim of this project is to engineer a reliable, highly manoeuvrable, and environmentally sustainable apparatus optimized for ground operations. Specifically, the research objectives focus on designing and fabricating a highly secure attachment mechanism for engaging the aircraft's nose landing gear.

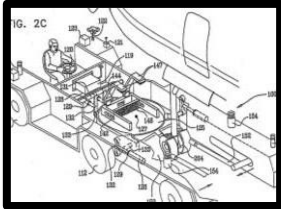

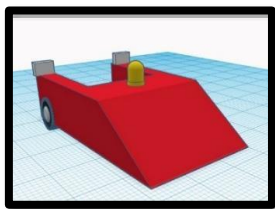
Furthermore, the project develops a robust, remote-controlled traction unit capable of executing precise ground maneuvers, including multidirectional translation, starting, stopping, reversing, and dynamic speed regulation. By removing human operators from the immediate hazard zone and allowing them to control the tug from a safe distance, the RCAT significantly mitigates the likelihood of ground incidents, thereby enhancing overall personnel safety during towing procedures.

The scope of the RCAT project is deliberately tailored to the operational requirements of lightweight aircraft frequently utilized by educational institutions, flying academies, and Approved Maintenance Training Organizations (AMTOs). Such institutions typically operate within spatial constraints where conventional, large-scale tow vehicles are rendered impractical, making the RCAT's compact footprint highly suitable for these environments [8]. Consequently, the RCAT features a specialized locking device engineered specifically for general aviation nose landing gear, accommodating tire diameters up to 36 cm, such as those found on the Cessna 172. An acknowledged limitation of this prototype is its operational threshold; while it offers a tailored and highly optimized solution for lightweight aviation, the RCAT is not structurally or mechanically suited for towing larger commercial airliners or heavy jet aircraft [2], [4], [8].

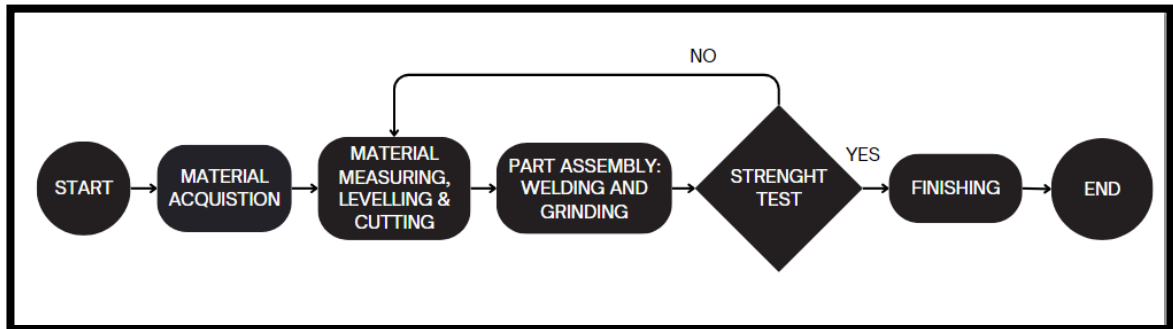
## 2.0 METHODOLOGY

The methodology for this project involves three (3) distinct stages: i) Design Requirements which employed set of questionnaire survey, ii) Design Generations using Morphological Matrices and lastly iii) Design Evaluation which using Pugh Evaluation Method. The prior art search was also conducted to establish design and features comparison between existing products in the market to the proposed design.

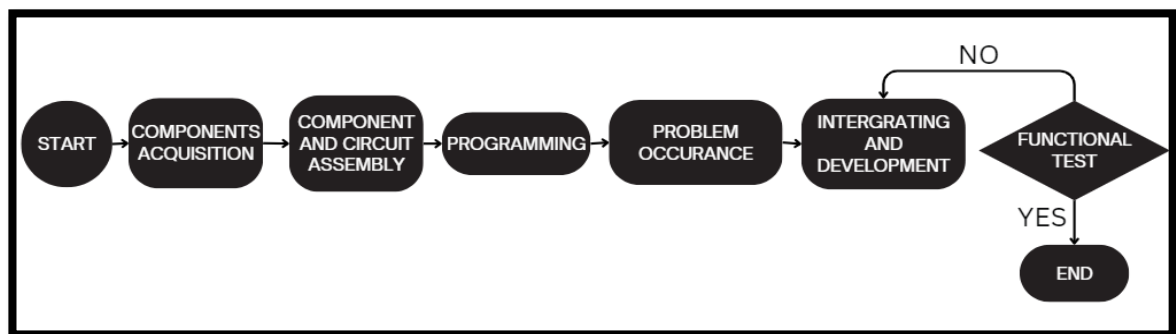
**Table 1.** Prior Art Search & Product Comparison

PRODUCT	Plane Tractor	TOWFLEXX	Remote Control Aircraft Tug
<b>Design</b>			
<b>Purpose</b>	Receiving a landing gear Of an airplane and towing it.	To move various aircraft or rotorcraft with 360 turn able wheel	To move a lightweight aircraft safely in tight turn
<b>Dimension</b>	N/A	1.200mm x 1.600mm x 450mm	36 inch x 30inch x 18inch
<b>Locking Device</b>	Fully Hydraulic secure door.	Hydraulic and mechanical locking	Mechanically locking with automatic electrical servo motor locking
<b>Movement mechanism</b>	Six tyre configurations controlled by steering	Tri-wheel with 360 turning	Dual integrated wheel configuration. One pilot wheel in front
<b>Configuration</b>	Towbarless	Towbarless	Towbarless
<b>Accessories</b>	Warning light	Warning alarm, Beacon light	Front Light, Fog light
<b>Control Mechanism</b>	Drive by person	Radio remote control	Radio remote control
<b>Battery Capacity</b>	Using engine	5km / 3.8mi	DUAL 12VDC IN SERIES – 150 Ahr

The development of RCAT can be divided into 2 different phases which is hardware and software development. The hardware part has been detailed out as in figure 2.1 whereas the software part can be referred in Figure 1 & 2.

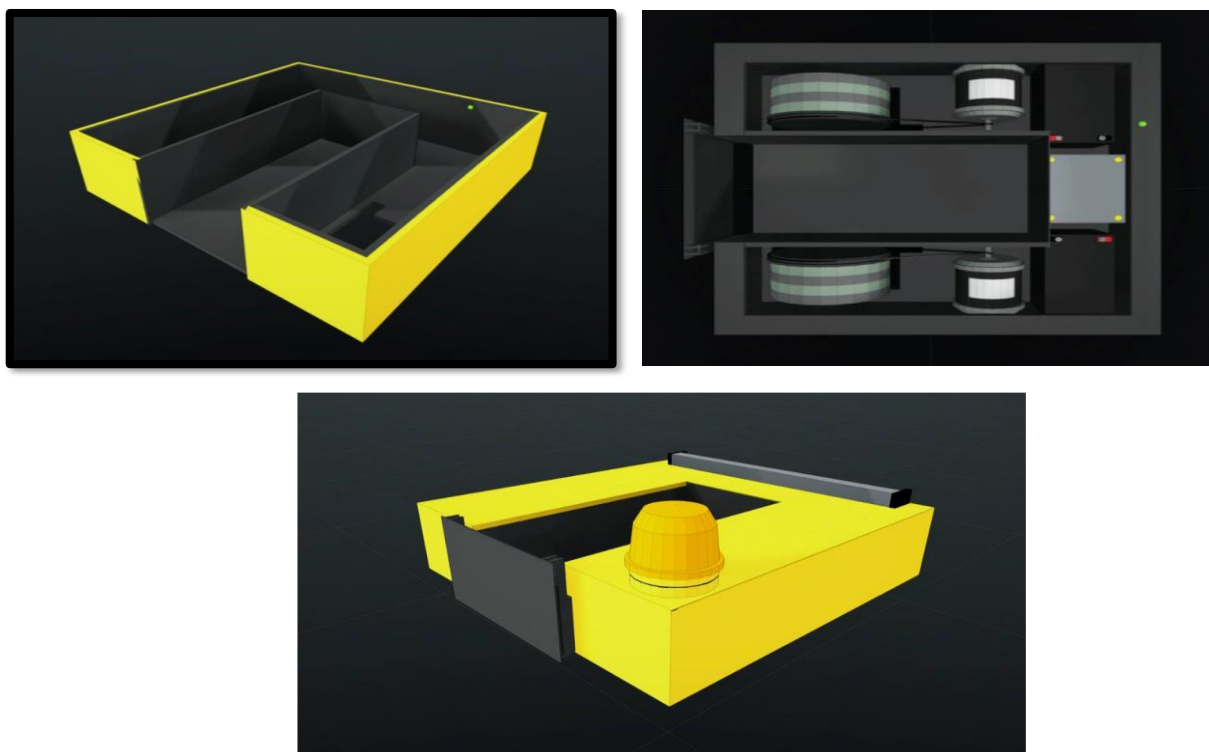


**Figure 1.** Project flowchart (Hardware Part)



**Figure 2.** Project flowchart (Software Part)

The design of the RCAT has been develop using AUTOCAD 2019 and the software programming involved Arduino microcontroller board. The hardware part involved BTS7960 motor driver, with the Arduino Uno R3 serving as the central control hub.



**Figure 3.** Drawings of RCAT (from left: Main Body, Internal Mechanism, Accessories)

Through sophisticated programming logic, the RCAT can accurately interpret commands from the remote-control system, facilitating seamless execution of desired movements. The adoption of the FlySky FS-i6X remote control system further enhances reliability and range, empowering operators with flexible and intuitive control capabilities [9]-[10].

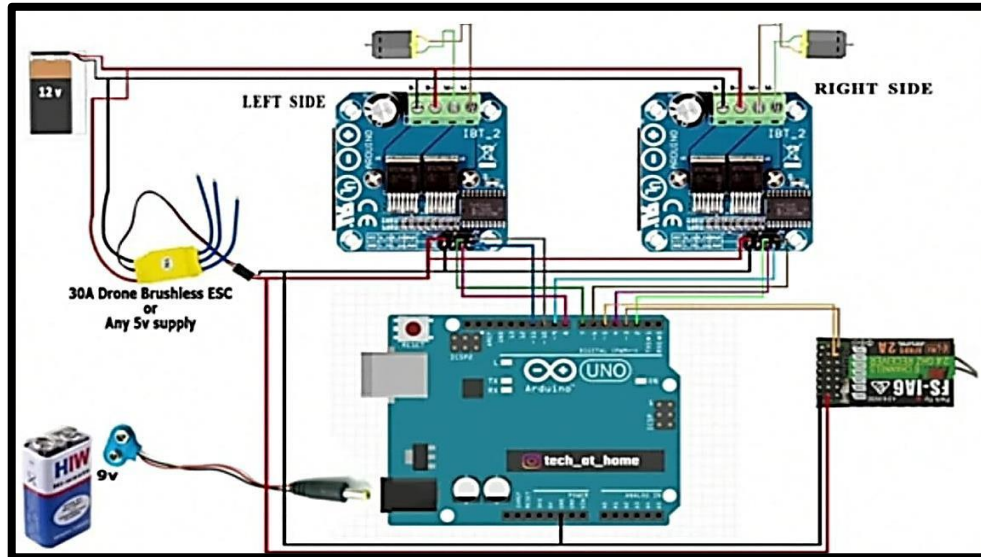


Figure 4. Circuit Diagram of RCAT

## 2.1 Product Testing

Upon the successful completion of the project, comprehensive testing was required to evaluate all functionalities and features. Initially, the structural integrity of the RCAT was examined. Multiple individuals stood on top of the apparatus simultaneously to verify its capacity to withstand substantial weight. The structure successfully demonstrated its ability to handle high-load conditions. Subsequently, the lighting systems, including the beacon and LED lights, were evaluated to ensure proper operation. This procedure was conducted to guarantee adequate illumination for personnel safety. The results indicated that all lighting components functioned correctly and remained in optimal condition.



Figure 5. RCAT Full Assembly

Following the structural and hardware evaluations, software testing was conducted to verify the standard operational movement of the RCAT. The system was further inspected to ensure the wheels rotated freely without interference from the associated fasteners and brackets. Additionally, the drive chain tension was assessed to prevent excessive slack. Finally, practical testing of the RCAT was executed by actively towing a real Cessna 172 aircraft within the hangar facility. The prototype was comprehensively evaluated across various operational parameters, including maneuverability, turning capabilities, and its capacity to sustain the actual weight of the Cessna 172. This evaluation was conducted in strict adherence to standard operating procedures for the ground handling of lightweight aircraft.

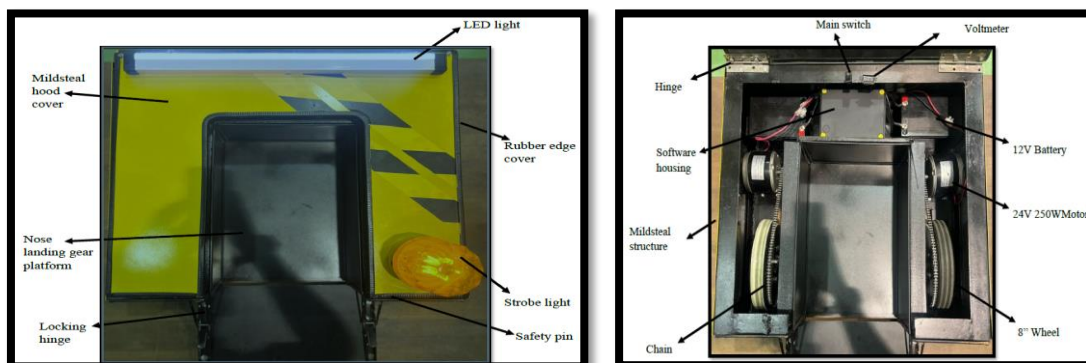


Figure 6. RCAT Towing the Cessna 172

### 3.0 RESULT

Table 2. Product Output Analysis

Parameters	Results	Remarks / Descriptions	Analysis/ Discussion
<b>Speed Limit</b>			
<b>Speed limit (unloaded)</b>	4.5 km/h	A maximum speed that a towing device can reach during unload.	In terms of speed limit, Remote Control Aircraft Tug (RCAT) is capable to reach 4.5km/h top speed during unloaded. However, its speed capability will drop up to 67% during FULL load condition.
<b>Speed limit (Partially Load)</b>	3.5 km/h	A maximum speed that a towing device can reach during 50% loaded.	
<b>Speed limit (Fully loaded)</b>	1.5 km/h	A maximum speed that a towing device can reach during FULL load.	
<b>Time of Operation</b>			
<b>Max Time</b>	25 minutes	A maximum time of operation that towing device can reach is 25 minutes	In terms of time operation, Remote Control Aircraft Tug (RCAT) is capable to reach about 25 minute. Even the load of the towing device is 40kg it can turning about 90 degree of angle during towing process. RCAT also can produce 24V of output power and 250W of power motor which is very capable for this device load.
<b>Weight / Load</b>	40kg	A maximum load of RCAT is 40kg.	
<b>Turning Radius</b>	90 degrees	A maximum turning radius of towing device can reach is 90 degrees.	
<b>Capacity / Volume</b>	20 Litres	A maximum capacity or volume that towing device can reach is 20 Litres.	
<b>Output Power / Voltage</b>	24V	A maximum output power that towing device can reach is 24V	
<b>Output Power Motor</b>	250W	A maximum output power of motor that towing device can reach is 250W	



**Figure 7.** Top View of RCAT (From left: External Part, Internal Part)

RCAT is an innovation in manoeuvring lightweight aircraft utilizing remote control technologies. In general, this product consists of two different compartments which had been attached. The primary section is the main frame section which would be the area where the nose landing gear is placed, and the part carries the load of the aircraft. Besides, the second section is the locking device which acts as a ramp for loading and unloading the aircraft wheel and securing it from the aircraft wheel falling back. For the achievement that RCAT structure archive are the maximum load that RCAT can easy pull is 600kg to 750kg. Moreover, for the maximum load for the forward light aircraft that RCAT can withstand and carry is about to 300kg to 450 kg.

Additionally, the locking device is the only section that makes up the RCAT. The locking device function makes sure that the aircraft's nose landing gear being towed and the tug have a steady and safe connection. In order to avoid any unintentional separation during the towing operation, this locking device is essential. To enable safe and regulated movement on the ground, the locking mechanism is made to firmly fasten the tug to the aircraft. The locking mechanism is intended to be simple to use. Simple engagement and disengagement processes are part of this and safety pin to secure the landing gear become falling back.

#### 4.0 CONCLUSION

Throughout the process of designing the real product of the Remote Control Aircraft Tug, the objectives and aim that were stated at the beginning of the work are considered successfully accomplished. The main purpose of this product mechanism is to design a Remote-Control Aircraft Tug with a locking device to secured the tyre while doing a towing process. The RCAT with a simplistic design it able manoeuvre a lightweight aircraft without any hindrance. The factor that approve that this innovation is a success was the ability of this product to manoeuvre a lightweight aircraft in shorter period of time, without damaging any components and sustainability to hold the load stress during manoeuvring the lightweight aircraft.

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