



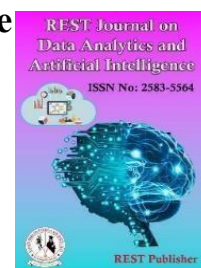
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# The Development and Assessment of Various Flight and Ground Testing Using the COPRAS Method

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**Abstract:** Flight and ground testing refers to a crucial phase in the development and assessment of various vehicles, systems, or technologies. It involves subjecting these entities to real-world conditions and controlled environments to evaluate their performance, functionality, safety, and other relevant attributes. **Flight Testing:** Flight testing typically involves taking aerial vehicles, such as airplanes, helicopters, drones, and spacecraft, into the air to gather data about their behaviour, capabilities, and limitations. Flight tests can assess parameters like endurance, manoeuvrability, stability, control, speed, altitude performance, and more. Engineers and researchers monitor the vehicle's response to different flight conditions, evaluate the accuracy of its navigation systems, and ensure that it meets safety standards. **Ground Testing:** Ground testing focuses on evaluating vehicles and systems in controlled environments on the ground. This can involve stationary or moving vehicles, like cars, trucks, autonomous vehicles, or robotics. Ground tests are designed to assess factors like engine performance, structural integrity, braking capabilities, sensor accuracy, and more. For example, automobile manufacturers conduct crash tests to determine how a vehicle's structure behaves under impact, ensuring passenger safety. Flight and ground testing hold immense significance in research and development across various industries, particularly aviation, aerospace, automotive, and robotics. These testing methodologies play a critical role in advancing technology, ensuring safety, and improving the overall performance of vehicles and systems. Here are some key reasons why flight and ground testing research is significant: **Validation of Design Concepts:** Flight and ground testing provide real-world validation of theoretical design concepts and simulations. This helps identify discrepancies between expected and actual performance, leading to refined and optimized designs. **Safety Assurance:** Testing ensures that vehicles and systems operate safely in various conditions. By identifying potential issues or weaknesses, researchers can address safety concerns before deploying products to the market or operational environments. **Unmanned Aerial Vehicle (UAV) endurance testing, Commercial airliner engine performance testing, Electric vertical takeoff and landing (eVTOL) prototype flight testing, Military fighter jet manoeuvrability testing and Autonomous ground vehicle navigation testing. Endurance (hours), Thrust-to-Weight Ratio, Vertical Takeoff and Landing (VTOL) Efficiency, Manoeuvrability Score and Navigation Accuracy (cm). the Ranking of Flight and Ground Testing. Commercial airliner engine performance testing is got the first rank whereas is the Electric vertical takeoff and landing (eVTOL) prototype flight testing is having the Lowest rank.**

**Keywords:** MCDM, Unmanned Aerial Vehicle (UAV) endurance testing, Commercial airliner engine performance testing, Electric vertical takeoff and landing (eVTOL) prototype flight testing and Military fighter jet manoeuvrability testing.

## 1. INTRODUCTION

Flight testing is a comprehensive process used to evaluate the performance, safety, and functionality of aircraft, spacecraft, drones, and other airborne systems. It involves taking the vehicle into the air to gather data on various aspects of its behaviour and capabilities. Flight testing is a critical phase in the development, certification, and improvement of aviation and aerospace technologies. **Performance Evaluation:** Flight tests assess parameters such as maximum speed, climb rate, ceiling altitude, and range. These evaluations help determine how well the vehicle performs under different flight conditions. **Manoeuvrability and Handling Qualities:** Test pilots and engineers analyse how the vehicle responds to different control inputs and flight manoeuvres [1]. This information helps optimize the vehicle's handling characteristics. **Stability and Control:** Flight testing assesses the stability and controllability of the vehicle. Engineers study factors like pitch, roll, and yaw stability to ensure safe and predictable flight behaviour. **Structural Integrity:** Flight tests monitor the vehicle's structural responses to various

forces, such as turbulence, high-G manoeuvres, and landing impacts. This data ensures that the structure can withstand operational stresses. Systems and Avionics: Flight testing evaluates onboard systems, avionics, and instrumentation [2]. This includes testing navigation, communication, and other electronic systems for accuracy and reliability. Aerodynamics: Flight tests help validate aerodynamic models and predictions. By measuring lift, drag, and other aerodynamic forces, engineers can refine design parameters. Environmental Conditions: Flight testing exposes the vehicle to different weather conditions, altitudes, and temperatures, ensuring it can perform reliably under diverse scenarios. Safety and Emergency Procedures: Flight tests include assessments of emergency procedures, such as engine failure and recovery, to ensure the safety of the crew and vehicle. Certification: Flight testing is a critical step in obtaining regulatory approvals and certifications from aviation authorities. It demonstrates that the vehicle meets safety and performance requirements [3]. Flight testing is conducted by experienced test pilots, flight engineers, and aerospace professionals. Data collected during flight tests, including sensor readings, instrument readings, and video recordings, is thoroughly analysed to make informed decisions about design modifications and improvements. Ground testing involves assessing the performance, functionality, safety, and durability of various vehicles, systems, or technologies in controlled environments on the ground. Unlike flight testing, which focuses on airborne vehicles, ground testing takes place without the vehicle being in motion [4]. This testing phase is essential to ensure that vehicles and systems meet design specifications, regulatory standards, and user expectations before they are deployed or operated. Functional Testing: Ground tests verify that the vehicle's systems, components, and features operate as intended. This includes testing engines, electronics, communication systems, sensors, and more. Structural Integrity: Engineers assess the vehicle's structure to ensure it can withstand operational stresses, loads, and impacts [5]. This can involve static testing (applying loads while the vehicle is stationary) and dynamic testing (simulating forces during movement). Environmental Simulation: Ground tests can recreate various environmental conditions, such as extreme temperatures, humidity, vibration, and exposure to harsh chemicals. This helps assess the vehicle's performance under different scenarios. Durability and Reliability: Ground testing helps identify potential weak points or areas of wear and tear. Durability tests involve subjecting the vehicle to repeated stress to assess its longevity, while reliability tests ensure consistent and dependable performance [6]. Safety Testing: Ground tests evaluate safety features and emergency procedures. This includes crash tests, airbag deployment tests, and simulations of emergency situations to ensure passenger and operator safety. Braking and Handling: Ground testing assesses braking performance, suspension systems, and handling characteristics. This is especially important for vehicles like cars, trucks, and off-road vehicles [7]. Noise and Vibration: Engineers measure noise levels and vibration characteristics to ensure comfort for passengers, operators, and nearby residents. This is relevant for vehicles operating near populated areas. Control Systems: Ground tests verify the effectiveness of control systems, such as steering mechanisms, braking systems, and autonomous driving technologies. Regulatory Compliance: Ground testing is often required to meet regulatory standards before vehicles or systems are approved for public use. Compliance with safety, emissions, and performance regulations is crucial. Prototype Development: Ground testing is integral to the development of prototypes, allowing engineers to refine designs and identify areas for improvement before mass production [8]. American Spacecraft: Operational engineering (OE) tasks and technology aim to demonstrate the capabilities of an American spacecraft. The objective is to verify the hardware's functionality, as well as its software-equipped capabilities. A couple was aboard the spacecraft, which carried a satellite into orbit, allowing the potential for servicing missions. During the OE task, a range of functions were performed autonomously, with some operations being carried out by the space shuttle. These tasks included spacecraft docking, the free-flying of the shuttle, capturing payloads, transferring fluids, and exchanging orbital replacement units (ORUs). One crucial aspect of the testing involved key technologies related to navigation, particularly sensors [9]. An Automatic Rendezvous and Capture Sensor System (ARCSS) with advanced sensors for automatic rendezvous and capture was developed by Boeing. Three different versions, featuring video and laser range finder capabilities, were crafted. The primary sponsor for OE work was the Défense Advanced Research Projects Agency (DARPA), providing funding. Boeing and NASA were also financial contributors. The NASA Marshall Space Flight Centre (MSFC) provided aircraft software, ground testing, and hardware and firmware support for the ARCSS. Moreover, MSFC conducted open-loop testing of flight robotics in the lab, as well as a comprehensive analysis of the navigation sensor system during mission flights [10]. The AVGS system serves the purpose of performing tasks in the vicinity of the spacecraft. Integrated with the ARCSS system, AVGS imparts knowledge to ASTRO, contributing to the guidance, navigation, and control (GN&C) system. AVGS incorporates both video and laser components, including corner cubes, a frame grabber, and processing software. These components work together to determine the relative positions between vehicles. AVGS uses a combination of small corner cubes for short-range target (SRT) measurements and larger corner cubes for long-range target (LRT) measurements, located on next Sat [11]. The corner cubes are strategically positioned on the spacecraft to enable reflections. Lasers with different wavelengths are fired at the corner-cube reflectors on next Sat. One laser wavelength is blocked by a filter in the corner-cubes, while the other wavelength passes through the filter and is reflected back to the sensor. AVGS captures an image during this process, allowing it to distinguish corner-cube reflections from the background. An algorithm utilizing reverse perspective is employed to determine the range,

azimuth, elevation, and attitude between AVGS and its targets on NEXT Sat. Once the cousin's position and approach data are calculated, this information, along with sensor data, is transmitted to the navigation system for analysis [12]. AVGS continuously monitors sensor position, home information, and maintenance data including sensor temperatures, voltages, and laser output forces. The thesis's main goal is to impartially assess the development of Chinese spacecraft over the past decade. It focuses on evaluating aspects like design, environmental impact, components, software, functionality, operations, and management, among seven distinct categories. The central objective is to delve into methods that comprehensively analyse reasons behind failures and their implications [13]. Unlike traditional approaches, this study employs a distinct classification method to pinpoint failure causes more precisely. By identifying these failure reasons, the research proposes specific enhancements related to design, engineering, and functionality, aiming to address fundamental failure factors. The provided data on failures covers the entirety of the spacecraft's lifecycle, encompassing ground-based Assembly, Integration, and Testing (AIT) activities, as well as subsystems, units, and vehicle acceptance testing. Additionally, the paper highlights the coordination involved in assembly and emphasizes the spacecraft's complete development process. Innovating to enhance efficiency and design novel vehicles, aircraft engineers are seeking innovative approaches to overcome conventional constraints [14]. The aim is to transcend limitations typically associated with traditional aircraft design. The challenges encompass issues rooted in rigid body mechanics and structural interactions. Addressing these concerns is imperative due to potential ramifications for flight quality. A prime example of this is the phenomenon known as Buffet-Induced Freedom Flutter (BFF), which has been observed for decades [15]. This unsettling event primarily occurs in aircraft with tails of relatively small size compared to wings, or those with higher ratios of wings to fuselage. BFF can lead to detrimental differential oscillations and even plane crashes when left unchecked. Historically, solutions to mitigate BFF predominantly involved making compromises in various facets of aircraft design. These attempts often incurred additional costs or modifications to configurations within the flight envelope. However, a promising alternative solution has emerged active suppression of BFF [16]. This method, which involves creating an appropriate dynamic model and control system for the vehicle, offers the potential to mitigate flutter-related constraints and facilitate smoother flight. This article explores the integration of flight and aeroelastic control through the Integrated Product Team (IPT) approach, as well as the dynamics model utilized within the IFAC (International Federation of Automatic Control) framework. The study presents how the IFAC and IPT jointly developed and validated a dynamic model through ground and air experiments [17].

## 2. MATERIALS AND METHOD

**2.1. Unmanned Aerial Vehicle (UAV) endurance testing:** Unmanned Aerial Vehicle (UAV) endurance testing is a crucial process in evaluating the operational capabilities and limitations of a drone's flight duration, battery life, and overall performance. Endurance testing helps manufacturers, researchers, and operators understand how long a UAV can fly on a single battery charge and how external factors might influence its flight time. Define the specific goals of the endurance testing, such as determining the maximum flight time under various conditions, evaluating the impact of payload weight on endurance, and assessing the effect of weather and environmental factors.

**2.2. Commercial airliner engine performance testing:** Commercial airliner engine performance testing is a critical process that ensures the safe, reliable, and efficient operation of aircraft engines used in commercial aviation. These tests help manufacturers, airlines, and aviation authorities validate the engine's design, efficiency, thrust output, fuel consumption, emissions, and overall performance under various operating conditions. Here are the key aspects and steps involved in commercial airliner engine performance testing: A specialized test cell, often referred to as a "engine test stand" or "engine test rig," is used to simulate actual flight conditions while the engine remains stationary. The test cell is equipped with advanced instrumentation and safety systems to monitor and control the engine during testing.

**2.3. Electric vertical takeoff and landing (eVTOL) prototype flight testing:** Electric Vertical Takeoff and Landing (eVTOL) prototype flight testing is a critical phase in the development of electric aircraft designed for vertical takeoff and landing capabilities. These aircraft, often referred to as air taxis or urban air mobility vehicles, have the potential to revolutionize urban transportation by offering efficient and environmentally friendly modes of travel. Here's an overview of the key aspects and steps involved in eVTOL prototype flight testing: Design and build a functional prototype of the eVTOL aircraft. This prototype incorporates the electric propulsion system, vertical lift mechanisms (such as rotors or ducted fans), flight control systems, avionics, and other critical components.

**2.4. Military fighter jet maneuverability testing:** Military fighter jet maneuverability testing is a crucial process that evaluates the performance and agility of fighter aircraft in various flight regimes and combat scenarios. This testing ensures that fighter jets can effectively maneuver in the air, evade threats, engage targets, and perform a wide range of aerial maneuvers essential for air superiority and combat missions. Here's an overview of the key aspects and steps involved in fighter jet maneuverability testing: Choose a representative fighter jet model for

testing, typically a prototype or an early production version. This aircraft should closely resemble the final design and incorporate the intended aerodynamic features and propulsion systems.

**2.5. Autonomous ground vehicle navigation testing:** Autonomous ground vehicle navigation testing is a critical process that assesses the capability of self-driving vehicles to navigate safely and efficiently in various environments without human intervention. These tests are essential for developing and validating the technology used in autonomous cars, trucks, and other ground-based vehicles. Here's an overview of the key aspects and steps involved in autonomous ground vehicle navigation testing: Choose a representative autonomous vehicle equipped with sensors, cameras, lidar, radar, GPS, and other necessary hardware for perception, localization, and control.

**2.6. Endurance (hours):** It seems like you've mentioned "Endurance (hours)" without providing additional context. Could you please provide more information or clarify your question? "Endurance (hours)" could refer to the duration of time that a system, vehicle, or device can operate before running out of power, fuel, or resources. This term is commonly used in various contexts, such as in unmanned aerial vehicles (UAVs), vehicles, batteries, and other applications. Please provide more details so that I can assist you accurately.

**2.7. Thrust-to-Weight Ratio:** The thrust-to-weight ratio (TWR) is a critical performance metric used in aviation and other fields involving propulsion systems. It's a ratio that compares the amount of thrust generated by an engine or propulsion system to the weight of the vehicle it's propelling. The thrust-to-weight ratio is often expressed as a numerical value and is commonly used to assess the capability of aircraft, rockets, and other vehicles to achieve desired levels of performance.

**2.8. Vertical Takeoff and Landing (VTOL) Efficiency:** Vertical Takeoff and Landing (VTOL) efficiency refers to the effectiveness and performance of an aircraft's ability to take off and land vertically, without the need for a runway or a long takeoff roll. VTOL efficiency is an essential consideration for aircraft that are designed to operate in confined spaces, urban environments, or locations with limited infrastructure. It involves optimizing various factors to ensure that the aircraft can achieve vertical takeoff and landing while maximizing fuel efficiency, payload capacity, and overall performance.

**2.9. Manoeuvrability Score:** A manoeuvrability score is a quantitative or qualitative measure used to assess the agility, responsiveness, and overall manoeuvring capability of vehicles, aircraft, or other objects. This score is often used to compare different vehicles' ability to perform specific manoeuvres or navigate through complex environments. The manoeuvrability score takes into account factors such as turning radius, roll rates, pitch rates, yaw rates, acceleration, and the vehicle's ability to respond to control inputs.

**2.10. Navigation Accuracy (cm):** Navigation accuracy refers to the precision with which a system, device, or vehicle can determine its location or position in a given space. It is typically measured in units of distance, such as centimetres (cm) or meters (m). Navigation accuracy is a crucial parameter in various applications, including aviation, maritime navigation, autonomous vehicles, robotics, surveying, and more. The accuracy of navigation systems is essential for ensuring safety, efficiency, and reliability in operations.

**2.11. Method:** COPRAS (Complex Proportionality Assessment) is one of the most used Multi-Criteria Decision Making (MCDM) methods, and the ratio of the best solution Determining the solution with the best rate in the set of possible alternatives by Provides a better alternative Bad Solution This technique has Decision making problems Various to solve used by researchers [18]. The COPRAS-G method requires identifying selection criteria, evaluating information related to these criteria, and developing methods to evaluate Meeting the participant's needs Criteria for doing in order to assess the overall performance of the surrogate. Decision analysis involves a Decision Maker (DM) Situation to do consider a particular set of alternatives and select one among several alternatives, usually with conflicting criteria. For this reason, the developed complexity proportionality assessment (COPRAS) method can be used [19]. In 1996 in Lithuania COPRAS (Complex Proportion evaluation) method was developed. construction, economics, real estate and management. One of the articles assesses the risks involved in construction projects. The assessment is based on various multi-objective assessment methods. The risk assessment indices are selected considering the interests, objectives and factors of the countries that influence the construction efficiency and real estate price increase [20] to describe and consider the task model. Complex Proportionality Assessment (COPRAS) Method Similar to any Many other criteria will make the decision (MCDM) tool, first Proposed COBRAS method of several related criteria Basically for alternatives Used to prioritize criterion weights. This method is better and Worst-Best Solutions Best decision considering Selecting alternatives [21]. Cobras approach is used for device tool choice; Because of this the triangle Ambiguous numbers are selected their computational performance. Three area specialists are selected to assign weights and by way of combining the fuzzy cobra's method, System 1 (MC1) and device 2(MC2) similarly are ranked, with way of machine three and four. -based totally approach is utilized in mixture with fuzzy. COPRAS assesses the complexity of consumer dating management (CRM) performance. A combined choice matrix is obtained from a panel of 20 specialists offered 3 options with set, and 5 criteria Assessment are done [22]. COPRAS to resolve MCDM issues, wherein the weights of the criteria and Performance ratings of alternatives are absolute Based on linguistic terms

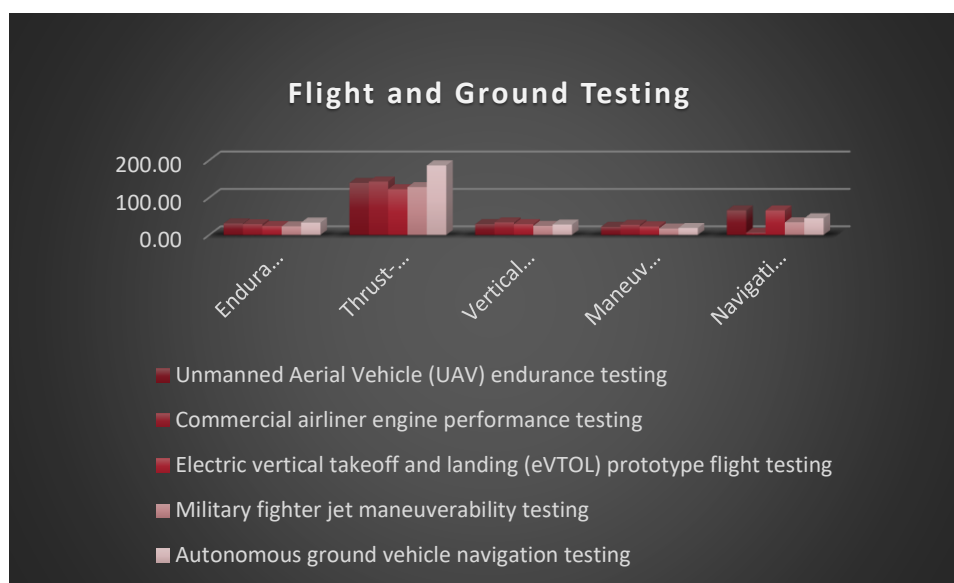
are calculated. Comparison of criteria Importance calculated and Cobras method become used to assess renovation strategies [23]. This has a look at ambitions to develop the impact of latest overall performance metrics in TPM and COPRAS in an ambiguous context Primarily multi-criteria selection based on opinions Use the do method. Looseness of paper is prepared as follows. Section 1 disturbance and Literature review describes. Section 2 Literature Evaluation and Cobras-G Approach Introducing the basics in sections three and four, Cobras G and the application of the proposed Cobras method [24]. Complex proportional estimation approach with gray c language Numbers (COPRAS-G) approach. Cobras- G's idea approach is based on standards values expressed in durations, actual decision-making conditions, and programs of Gray Systems Theory. Diploma [25]. COPRAS method changed into the most relevant social media platform Rank and choose is used. Proposed Applicability of the structure We proved and proved the character [26]. COPRAS (Complex Proportionality Assessment) To examine Cumulative of an alternative Performance, it is essentially become aware of the maximum vital criteria, examine the options and compare the facts Depending on those criteria to fulfil the wishes of the DMs to compare grades evaluation involves a situation in which a DM must pick amongst several downloaded alternatives given a selected set of commonly conflicting standards. For this motive, the developed complex proportionality evaluation (COPRAS) method can be used in real situations, alternatives The criteria for assessment are vague is related to the factor, And the values of the standards are real Cannot be expressed with numbers [27].

### 3. RESULTS AND DISCUSSION

TABLE 1. Flight and Ground Testing

	<b>Endurance (hours)</b>	<b>Thrust-to-Weight Ratio</b>	<b>Vertical Take-off and Landing (VTOL) Efficiency</b>	<b>Manoeuvrability Score</b>	<b>Navigation Accuracy (cm)</b>
Unmanned Aerial Vehicle (UAV) endurance testing	31.08	139.53	29.15	22.05	66.00
Commercial airliner engine performance testing	29.12	142.97	33.69	27.30	6.00
Electric vertical takeoff and landing (eVTOL) prototype flight testing	24.08	122.58	29.18	23.10	66.00
Military fighter jet maneuverability testing	23.17	128.28	24.60	17.59	34.00
Autonomous ground vehicle navigation testing	33.33	186.41	27.96	18.89	45.00

Table 1 shows the Flight and Ground Testing for COPRAS Method Endurance (hours) in Autonomous ground vehicle navigation testing (33.33 hours) is showing the highest value and Electric vertical takeoff and landing (eVTOL) prototype flight testing (24.08 hours) is showing the lowest value. Thrust-to-Weight Ratio in Autonomous ground vehicle navigation testing (186.41) is showing the highest value and Electric vertical takeoff and landing (eVTOL) prototype flight testing (122.58) is showing the lowest value. Vertical Takeoff and Landing (VTOL) Efficiency in Commercial airliner engine performance testing (33.69) is showing the highest value and Military fighter jet maneuverability testing (24.60) is showing the lowest value. Maneuverability Score in Commercial airliner engine performance testing (27.30) is showing the highest value and Military fighter jet maneuverability testing (17.59) is showing the lowest value. Navigation Accuracy (cm) in Autonomous ground vehicle navigation testing (45.00 cm) is showing the highest value and Commercial airliner engine performance testing (6.00 cm) is showing the lowest value.



**FIGURE 1.** Flight and Ground Testing

Figure 1 shows the Flight and Ground Testing for COPRAS Method Endurance (hours) in Autonomous ground vehicle navigation testing (33.33 hours) is showing the highest value and Electric vertical takeoff and landing (eVTOL) prototype flight testing (24.08 hours) is showing the lowest value. Thrust-to-Weight Ratio in Autonomous ground vehicle navigation testing (186.41) is showing the highest value and Electric vertical takeoff and landing (eVTOL) prototype flight testing (122.58) is showing the lowest value. Vertical Takeoff and Landing (VTOL) Efficiency in Commercial airliner engine performance testing (33.69) is showing the highest value and Military fighter jet maneuverability testing (24.60) is showing the lowest value. Maneuverability Score in Commercial airliner engine performance testing (27.30) is showing the highest value and Military fighter jet maneuverability testing (17.59) is showing the lowest value. Navigation Accuracy (cm) in Autonomous ground vehicle navigation testing (45.00 cm) is showing the highest value and Commercial airliner engine performance testing (6.00 cm) is showing the lowest value.

**TABLE 2.** Normalized Data

	Endurance (hours)	Thrust-to-Weight Ratio	Vertical Take-off and Landing (VTOL) Efficiency	Manoeuvrability Score	Navigation Accuracy (cm)
Unmanned Aerial Vehicle (UAV) endurance testing	0.22	0.19	0.20	0.20	0.30
Commercial airliner engine performance testing	0.21	0.20	0.23	0.25	0.03
Electric vertical take-off and landing (eVTOL) prototype flight testing	0.17	0.17	0.20	0.21	0.30
Military fighter jet manoeuvrability testing	0.16	0.18	0.17	0.16	0.16
Autonomous ground vehicle navigation testing	0.24	0.26	0.19	0.17	0.21

Table 2 shows the Normalized Data for Flight and Ground Testing in Unmanned Aerial Vehicle (UAV) endurance testing, Commercial airliner engine performance testing, Electric vertical takeoff and landing (eVTOL) prototype flight testing, Military fighter jet maneuverability testing and Autonomous ground vehicle navigation testing. Endurance (hours), Thrust-to-Weight Ratio, Vertical Takeoff and Landing (VTOL) Efficiency, Maneuverability Score and Navigation Accuracy (cm) it is also Normalized value.

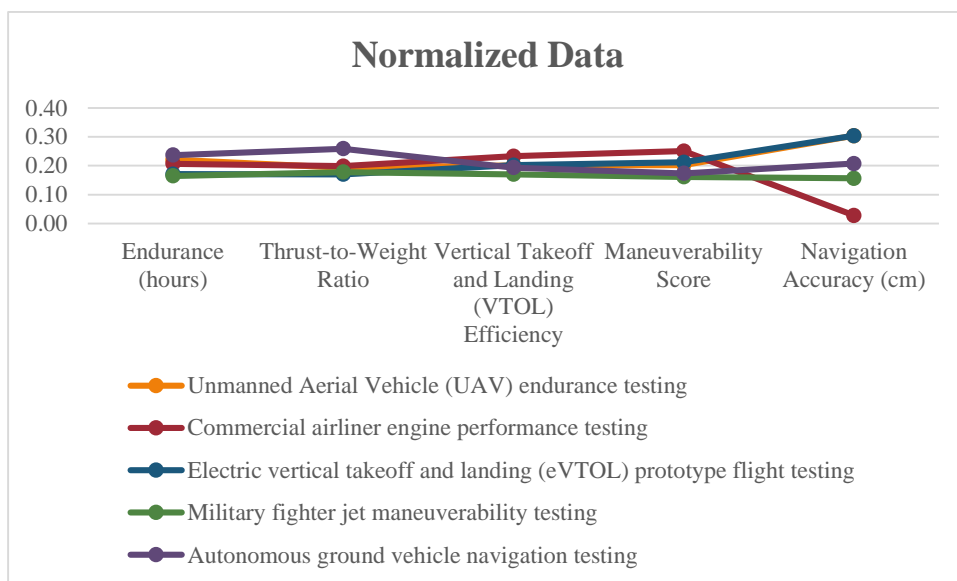


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TABLE 3. Weightages

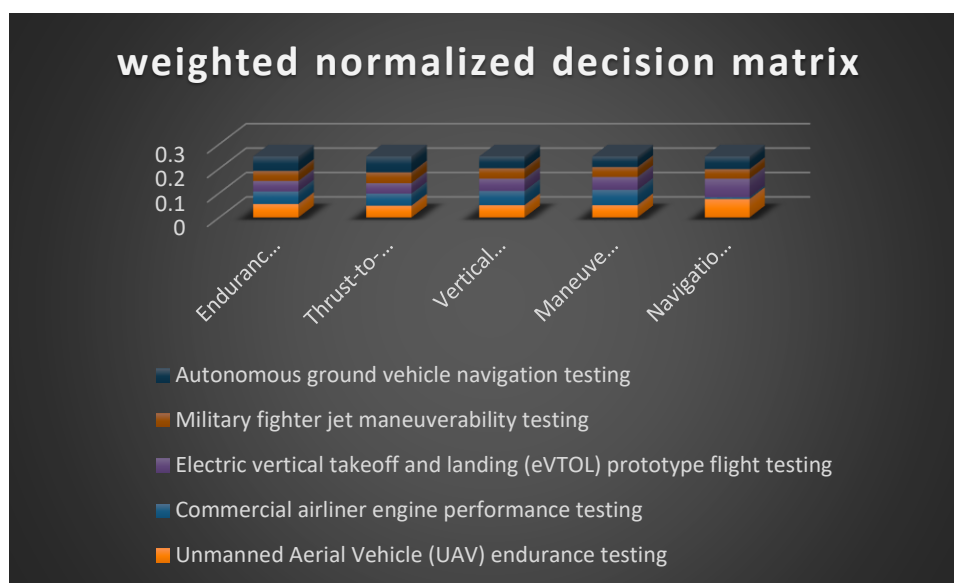
Weightages				
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25

Table 3 shows Weightages used for the analysis. We taken same weights for all the parameters for the analysis

TABLE 4. Weighted normalized decision matrix

Weighted normalized decision matrix				
0.06	0.05	0.05	0.05	0.08
0.05	0.05	0.06	0.06	0.01
0.04	0.04	0.05	0.05	0.08
0.04	0.04	0.04	0.04	0.04
0.06	0.06	0.05	0.04	0.05

Table 4 shows the weighted normalized decision matrix for Flight and Ground Testing in Unmanned Aerial Vehicle (UAV) endurance testing, Commercial airliner engine performance testing, Electric vertical takeoff and landing (eVTOL) prototype flight testing, Military fighter jet maneuverability testing and Autonomous ground vehicle navigation testing. Endurance (hours), Thrust-to-Weight Ratio, Vertical Takeoff and Landing (VTOL) Efficiency, Maneuverability Score and Navigation Accuracy (cm) it is also weighted normalized decision matrix value.



**FIGURE 3.** Weighted Normalized Decision Matrix

Figure 3 shows the weighted normalized decision matrix for Flight and Ground Testing in Unmanned Aerial Vehicle (UAV) endurance testing, Commercial airliner engine performance testing, Electric vertical takeoff and landing (eVTOL) prototype flight testing, Military fighter jet maneuverability testing and Autonomous ground vehicle navigation testing. Endurance (hours), Thrust-to-Weight Ratio, Vertical Takeoff and Landing (VTOL) Efficiency, Maneuverability Score and Navigation Accuracy (cm) it is also weighted normalized decision matrix value.

**TABLE 5.** Flight and Ground Testing  $B_i$ ,  $C_i$ ,  $\text{Min}(C_i)/C_i$

	$B_i$	$C_i$	$\text{Min}(C_i)/C_i$
Unmanned Aerial Vehicle (UAV) endurance testing	0.154	0.127	0.5493
Commercial airliner engine performance testing	0.160	0.070	1.0000
Electric vertical takeoff and landing (eVTOL) prototype flight testing	0.136	0.129	0.5391
Military fighter jet maneuverability testing	0.128	0.080	0.8746
Autonomous ground vehicle navigation testing	0.172	0.095	0.7308
	$\text{min}(C_i)*\text{sum}(C_i)$	0.0348	3.6938

Table 5 shows Flight and Ground Testing  $B_i$ ,  $C_i$ ,  $\text{Min}(C_i)/C_i$  in Unmanned Aerial Vehicle (UAV) endurance testing, Commercial airliner engine performance testing, Electric vertical takeoff and landing (eVTOL) prototype flight testing, Military fighter jet maneuverability testing and Autonomous ground vehicle navigation testing. Endurance (hours), Thrust-to-Weight Ratio, Vertical Takeoff and Landing (VTOL) Efficiency, Maneuverability Score and Navigation Accuracy (cm) it is sum of minimum value.

**TABLE 6.** Final Result of Flight and Ground Testing

	$Q_i$	$U_i$	Rank
Unmanned Aerial Vehicle (UAV) endurance testing	0.228	77%	4
Commercial airliner engine performance testing	0.295	100%	1
Electric vertical takeoff and landing (eVTOL) prototype flight testing	0.209	71%	5
Military fighter jet maneuverability testing	0.247	84%	3
Autonomous ground vehicle navigation testing	0.271	92%	2

Table 6 shows the final result of COPRAS for Flight and Ground Testing.  $Q_i$  in Commercial airliner engine performance testing is having is Higher Value and Electric vertical takeoff and landing (eVTOL) prototype flight testing is having

Lower value.  $U_i$  in Commercial airliner engine performance testing is having is Higher Value and Electric vertical takeoff and landing (eVTOL) prototype flight testing is having Lower value.

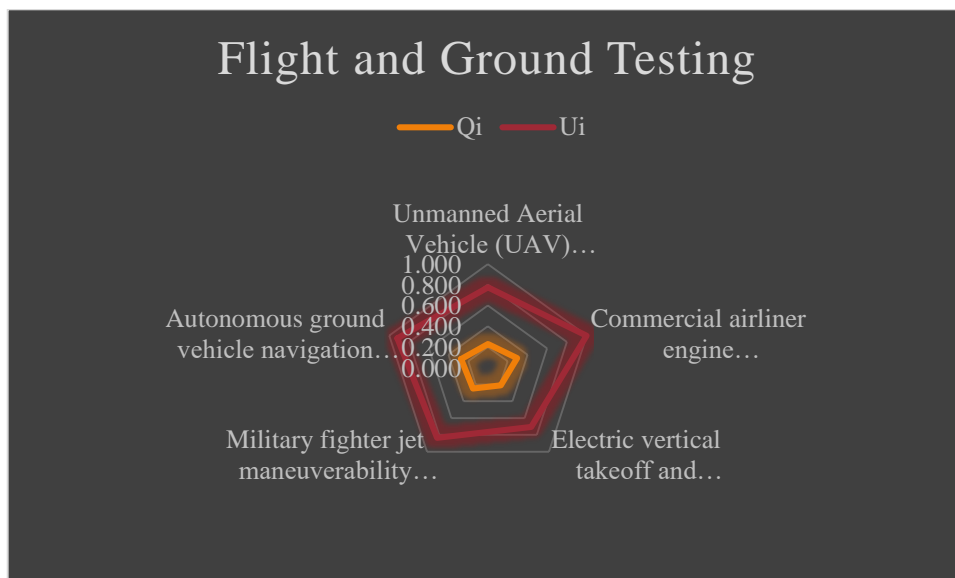


FIGURE 4. Flight and Ground Testing Qi, Ui

Figure 4 shows the final result of COPRAS for Flight and Ground Testing.  $Q_i$  in Commercial airliner engine performance testing is having is Higher Value and Electric vertical takeoff and landing (eVTOL) prototype flight testing is having Lower value.  $U_i$  in Commercial airliner engine performance testing is having is Higher Value and Electric vertical takeoff and landing (eVTOL) prototype flight testing is having Lower value.

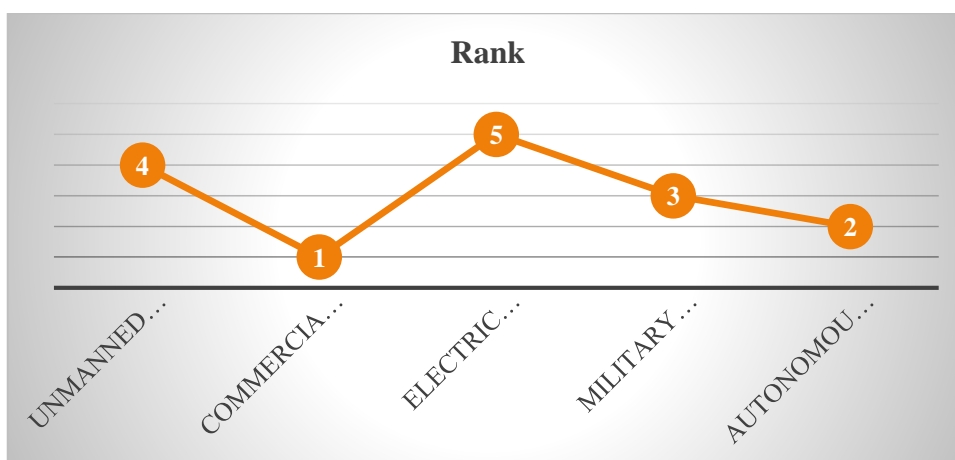


FIGURE 5. Rank

Figure 5 Shows the Ranking of Flight and Ground Testing. Commercial airliner engine performance testing is got the first rank whereas is the Electric vertical takeoff and landing (eVTOL) prototype flight testing is having the Lowest rank.

#### 4. CONCLUSION

Flight testing is a comprehensive process used to evaluate the performance, safety, and functionality of aircraft, spacecraft, drones, and other airborne systems. It involves taking the vehicle into the air to gather data on various aspects of its behaviour and capabilities. Flight testing is a critical phase in the development, certification, and improvement of aviation and aerospace technologies., Performance Evaluation: Flight tests assess parameters such as maximum speed, climb rate, ceiling altitude, and range. These evaluations help determine how well the vehicle performs under different flight conditions. Manoeuvrability and Handling Qualities: Test pilots and engineers analyse how the vehicle responds to different control inputs and flight manoeuvres [1]. This information helps optimize the vehicle's handling characteristics. Stability and Control: Flight testing assesses the stability and controllability of the vehicle. Engineers study factors like pitch, roll, and yaw stability to ensure safe and

predictable flight behaviour. **Structural Integrity:** Flight tests monitor the vehicle's structural responses to various forces, such as turbulence, high-G manoeuvres, and landing impacts. This data ensures that the structure can withstand operational stresses. **Systems and Avionics:** Flight testing evaluates onboard systems, avionics, and instrumentation. **Commercial airliner engine performance testing** is a critical process that ensures the safe, reliable, and efficient operation of aircraft engines used in commercial aviation. These tests help manufacturers, airlines, and aviation authorities validate the engine's design, efficiency, thrust output, fuel consumption, emissions, and overall performance under various operating conditions. Here are the key aspects and steps involved in commercial airliner engine performance testing: A specialized test cell, often referred to as a "engine test stand" or "engine test rig," is used to simulate actual flight conditions while the engine remains stationary. The test cell is equipped with advanced instrumentation and safety systems to monitor and control the engine during testing. The thrust-to-weight ratio (TWR) is a critical performance metric used in aviation and other fields involving propulsion systems. It's a ratio that compares the amount of thrust generated by an engine or propulsion system to the weight of the vehicle it's propelling. The thrust-to-weight ratio is often expressed as a numerical value and is commonly used to assess the capability of aircraft, rockets, and other vehicles to achieve desired levels of performance. **the Ranking of Flight and Ground Testing.** Commercial airliner engine performance testing is got the first rank whereas is the Electric vertical takeoff and landing (eVTOL) prototype flight testing is having the Lowest rank.

## REFERENCES

- [1]. Huebner, Lawrence D., Kenneth E. Rock, Edward G. Ruf, David W. Witte, and Earl H. Andrews Jr. "Hyper-X flight engine ground testing for flight risk reduction." *Journal of Spacecraft and Rockets* 38, no. 6 (2001): 844-852.
- [2]. Howard, Richard T., Andrew F. Heaton, Robin M. Pinson, and Connie K. Carrington. "Orbital express advanced video guidance sensor." In *2008 IEEE Aerospace Conference*, pp. 1-10. IEEE, 2008.
- [3]. Johansson, K., P. Dyreklev, O. Granbom, M. C. Calver, S. Fournine, and O. Feuillatre. "In-flight and ground testing of single event upset sensitivity in static RAMs." *IEEE Transactions on Nuclear Science* 45, no. 3 (1998): 1628-1632.
- [4]. Ji, Xin-Yan, Yun-Ze Li, Guo-Qing Liu, Jing Wang, Shu-Hong Xiang, Xiao-Ning Yang, and Yan-Qiang Bi. "A brief review of ground and flight failures of Chinese spacecraft." *Progress in Aerospace Sciences* 107 (2019): 19-29.
- [5]. Gardner, A., J. Steelant, A. Paull, and K. Hannemann. "Ground testing of the HyShot supersonic combustion flight experiment in HEG and comparison with flight data." In *40th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit*, p. 3345. 2004.
- [6]. Burnett, Edward, Chris Atkinson, Jeff Beranek, Brian Sibbitt, Brian Holm-Hansen, and Leland Nicolai. "N dof simulation model for flight control development with flight test correlation." In *AIAA Modeling and Simulation Technologies Conference*, p. 7780. 2010.
- [7]. Gu, Yu, Brad Seanor, Giampiero Campa, Marcello R. Napolitano, Larry Rowe, Srikanth Gururajan, and Sheng Wan. "Design and flight testing evaluation of formation control laws." *IEEE Transactions on Control Systems Technology* 14, no. 6 (2006): 1105-1112.
- [8]. Brown, T. Gordon, and Bradford S. Davis. "Dynamic high-g loading of MEMS sensors: ground and flight testing." In *Materials and Device Characterization in Micromachining*, vol. 3512, pp. 228-235. SPIE, 1998.
- [9]. LaBel, Kenneth A., Paul W. Marshall, Cheryl J. Marshall, Mary D'Ordine, Martin Carts, Gary Lum, Hak S. Kim et al. "Proton-induced transients in optocouplers: In-flight anomalies, ground irradiation test, mitigation and implications." *IEEE transactions on Nuclear Science* 44, no. 6 (1997): 1885-1892.
- [10]. Hald, Hermann, and Thomas Ullmann. "Reentry flight and ground testing experience with hot structures of C/C-SiC material." In *44th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, p. 1667. 2003.
- [11]. Bharani, Neha. "Software Quality Measurement using Complexity Analysis of Various Software Engineering Phases." (2020).
- [12]. Nayeemuddin, Mr, and Mr Abdul Nazeer. "To study the effect of low velocity impacts on composite material buy using Finite element analysis software LSDYNA." *Iosr Journal Of Mechanical And Civil Engineering (Iosr-Jmce)* E-Issn: 2278-1684.
- [13]. Iliff, Kenneth, and Mary Shafer. "Space Shuttle hypersonic flight research and the comparison to ground test results." In *17th Aerospace Ground Testing Conference*, p. 3988. 1992.
- [14]. Kimmel, Roger L., David W. Adamczak, Matthew P. Borg, Joseph S. Jewell, Thomas J. Juliano, Scott A. Stanfield, and Karen T. Berger. "First and fifth hypersonic international flight research experimentation's flight and ground tests." *Journal of Spacecraft and Rockets* 56, no. 2 (2019): 421-431.
- [15]. Jyothi, P., and G. Pradeepini. "Classification of normal/abnormal heart sound recording through convolution neural network through the integration of baseline and adaboost classifier." In *Proceedings of the 2nd International Conference on Computational and Bio Engineering: CBE 2020*, pp. 441-447. Singapore: Springer Singapore, 2021.
- [16]. Dolvin, Douglas. "Hypersonic international flight research and experimentation technology development and flight certification strategy." In *16th AIAA/DLR/DGLR International Space Planes and Hypersonic Systems and Technologies Conference*, p. 7228. 2009.

- [17]. Wadhams, Timothy, Matthew MacLean, Michael Holden, and Eric Mundy. "Pre-flight ground testing of the full-scale FRESH FX-1 at fully duplicated flight conditions." In 37th AIAA fluid dynamics conference and exhibit, p. 4488. 2007.
- [18]. Salma, Umme. "Analysis of a Drilling Hybrid Aluminum Metal Matrix Composites by Using SPSS." (2023).
- [19]. Gardner, A., J. Steelant, A. Paull, and K. Hannemann. "Ground testing of the HyShot supersonic combustion flight experiment in HEG and comparison with flight data." In 40th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, p. 3345. 2004.
- [20]. Jyothi, P. "Efficient Technique to optimize cloud storage in multi-Tenant Environment." *IJCERT ISSN (O): 2349-7084* (2016): 23-29.
- [21]. Dantsker, Or D., Marco Caccamo, Moiz Vahora, and Renato Mancuso. "Flight & ground testing data set for an unmanned aircraft: Great planes avistar elite." In AIAA Scitech 2020 Forum, p. 0780. 2020.
- [22]. Priya, R. "Stress coping mechanisms adopted by banking sector employees for downsize the stress: A study." *IOSR J Busi Mgt* 19 (2017): 13-7.
- [23]. Yalavarthi, Sreekanth, and Rambabu Inaganti. "Navigating Emerging Threats: Strategies for Cybersecurity in AI-Driven Healthcare Diagnostics and FDA Compliance." In *AI-Driven Healthcare Cybersecurity and Privacy*, pp. 327-342. IGI Global Scientific Publishing, 2025.
- [24]. Manikandan, G., and S. Srinivasan. "Traffic control by bluetooth enabled mobile phone." *International Journal of Computer and Communication Engineering* 1, no. 1 (2012): 66.
- [25]. Swihart, Donald E., Arthur F. Barfield, Edward M. Griffin, Richard C. Lehmann, Shawn C. Whitcomb, Billie Flynn, Mark A. Skoog, and Kevin E. Processor. "Automatic ground collision avoidance system design, integration, & flight test." *IEEE Aerospace and Electronic Systems Magazine* 26, no. 5 (2011): 4-11.
- [26]. Yazdani, Morteza, Ali Alidoosti, and Edmundas Kazimieras Zavadskas. "Risk analysis of critical infrastructures using fuzzy COPRAS." *Economic research-Ekonomska istraživanja* 24, no. 4 (2011): 27-40.
- [27]. Aghdaie, Mohammad Hasan, Sarfaraz Hashemkhani Zolfani, and Edmundas Kazimieras Zavadskas. "Market segment evaluation and selection based on application of fuzzy AHP and COPRAS-G methods." *Journal of Business Economics and Management* 14, no. 1 (2013): 213-233.
- [28]. Evangeline, Sahana, Vibhav S. Angadi, K. Akshaya, H. Snehith, and D. Annapurna. "with Q-Learning Protocol Using NS3." In *Proceedings of International Conference on Communication and Computational Technologies: ICCCT 2024, Volume 2*, vol. 1122, p. 53. Springer Nature, 2025.
- [29]. Arunadevi, R., and G. S. Subashini. "Virtual Teams Effectiveness In The Selected IT Companies In South India." *Journal of Namibian Studies* 38 (2023).
- [30]. Jones, Christonson Berin, and Chakravarthi Murugamani. "Malaria parasite detection on microscopic blood smear images with integrated deep learning algorithms." *Int. Arab J. Inf. Technol.* 20, no. 2 (2023): 170-179.
- [31]. Bharani, Neha. *Complexity study of software engineering phases and software quality*. Book Rivers, 2022.
- [32]. Kishore, V. Vijaya, G. Hema Padmini, I. Sudharshan, K. Tejaswini, M. Roopa, and Rambabu Inaganti. "Predicting Knee Osteoarthritis Grades using Deep Learning-A Extensive Examination." In *International Conference on Computational Innovations and Emerging Trends (ICCIET-2024)*, pp. 734-744. Atlantis Press, 2024.
- [33]. Varma, P. Bharat Siva, Prathap Adimoolam, Yamini Lahari Marna, Anantharamaiah Vengala, VS Divya Sundar, and MVT Ram Pavan Kumar. "Enhancing robust object detection in weather-impacted environments using deep learning techniques." In *2024 2nd International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS)*, pp. 599-604. IEEE, 2024.
- [34]. Kildienė, Simona, Arturas Kaklauskas, and Edmundas Kazimieras Zavadskas. "COPRAS based comparative analysis of the European country management capabilities within the construction sector in the time of crisis." *Journal of Business Economics and Management* 12, no. 2 (2011): 417-434.
- [35]. Das, Manik Chandra, Bijan Sarkar, and Siddhartha Ray. "A framework to measure relative performance of Indian technical institutions using integrated fuzzy AHP and COPRAS methodology." *Socio-Economic Planning Sciences* 46, no. 3 (2012): 230-241.
- [36]. Praiselin, EJ Honesty, Dr G. Manikandan, Vilma Veronica, and Ms S. Hemalatha. "Sign language detection and recognition using media pipe and deep learning algorithm." *International Journal of Scientific Research in Science and Technology* 11, no. 2 (2024): 123-130.
- [37]. Ragavan, V. K., N. S. Nithya, Anantharamaiah Vengala, Balambigai Subramanian, and C. Ambhika. "Refractive Index Biosensor-Based Detection of Mycobacterium Tuberculosis Using Sea Lion Political Optimizer and Deep Learning." *Plasmonics* (2025): 1-19.
- [38]. Mekala, Sreenivas, Vishnu Vardan Bulusu, and Raghunadha Reddy. "A survey on authorship attribution approaches." *Int. J. Comput. Eng. Res. (IJCER)* 8, no. 8 (2018).
- [39]. Dhiman, Harsh S., and Dipankar Deb. "Fuzzy TOPSIS and fuzzy COPRAS based multi-criteria decision making for hybrid wind farms." *Energy* 202 (2020): 117755.
- [40]. Suganya, B., R. Gopi, A. Ranjith Kumar, and Gavendra Singh. "Dynamic task offloading edge-aware optimization framework for enhanced UAV operations on edge computing platform." *Scientific Reports* 14, no. 1 (2024): 16383.
- [41]. Rani, Dr V. Vasudha, D. Vasavi, and K. Kumar. "Significance of multilayer perceptron model for early detection of diabetes over ml methods." *J. Univ. Shanghai Sci. Technol* 23, no. 08 (2021): 148-160.
- [42]. Bogireddy, Srinivasa Rao, and H. Murari. "A Hyperparameters tuned ML algorithm for fraud identification in banking and financial transactions." *International Journal of Innovative Science and Research Technology (IJISRT)* (2024): 1619-1625.
- [43]. Fouladgar, Mohammad Majid, Abdolreza Yazdani-Chamzini, Ali Lashgari, Edmundas Kazimieras Zavadskas, and Zenonas Turskis. "Maintenance strategy selection using AHP and COPRAS under fuzzy environment." *International journal of strategic property management* 16, no. 1 (2012): 85-104.

- [44].Turanoglu Bekar, Ebru, Mehmet Cakmakci, and Cengiz Kahraman. "Fuzzy COPRAS method for performance measurement in total productive maintenance: a comparative analysis." *Journal of Business Economics and Management* 17, no. 5 (2016): 663-684.
- [45].GS, Subashini, and P. Vijayalakshmi. "A Study on Gender Disparity and Female Agriculture Worker Participation in Decision Making at Thanjavur District." *Journal of the Gujarat Research Society* 21, no. 12 (2019): 1-9.
- [46].Kumar, KRN Kiran, and K. Bhavani. "Folded spined cube: new topology in interconnection networks." In *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)*, pp. 314-319. IEEE, 2022.
- [47].Manikandan, G., D. Karunkuzhali, D. Geetha, and V. Kavitha. "Design of an IoT approach for security surveillance system for industrial process monitoring using Raspberry-Pi." In *AIP Conference Proceedings*, vol. 2519, no. 1, p. 030024. AIP Publishing LLC, 2022.
- [48].Zolfani, Sarfaraz Hashemkhani, Nahid Rezaeiniya, Mohammad Hasan Aghdaie, and Edmundas Kazimieras Zavadskas. "Quality control manager selection based on AHP-COPRAS-G methods: a case in Iran." *Economic research-Ekonomska istraživanja* 25, no. 1 (2012): 72-86.
- [49].Mohan, VakaMurali, MalliKarjuna Reddy, and KRN Kiron Kumar. "A New Approach to Optical Networks Security: Attack-Aware Routing and Wavelength Assignment." In *IJCA Special Issues on "2nd National Conference-Computing, Communication and Sensor Network" CCSN*. 2011.
- [50].Bogireddy, Srinivasa Rao, and Haritha Murari. "Machine learning for predictive telemarketing: Boosting campaign effectiveness in banking." In *2024 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)*, pp. 1-6. IEEE, 2024.
- [51].Tavana, Madjid, Ehsan Momeni, Nahid Rezaeiniya, Seyed Mostafa Mirhedayatian, and Hamidreza Rezaeiniya. "A novel hybrid social media platform selection model using fuzzy ANP and COPRAS-G." *Expert Systems with Applications* 40, no. 14 (2013): 5694-5702.
- [52].Murugamani, C., Santosh Kumar Sahoo, Pravin R. Kshirsagar, Boppuru Rudra Prathap, Saiful Islam, Quadri Noorulhasan Naveed, Mohammad Rashid Hussain, Bui Thanh Hung, and Dawit Mamiru Teressa. "Wireless communication for robotic process automation using machine learning technique." *Wireless Communications and Mobile Computing* 2022, no. 1 (2022): 4723138.
- [53].Bogireddy, Srinivasa Rao, and H. Murari. "A Hyperparameters tuned ML algorithm for fraud identification in banking and financial transactions." *International Journal of Innovative Science and Research Technology (IJISRT)* (2024): 1619-1625.
- [54].Mahendiran, A., and R. Priya. "Attitude Towards the use of Information and Communication Technologies (ICT): Learners Perspective in Rural Arts and Science Colleges." *International Journal of Management Studies, VI (1)* 83 (2020).
- [55].Kumar, A. Ranjith, and A. Sivagami. "Fuzzy based malicious node detection and security-aware multipath routing for wireless multimedia sensor network." *Multimedia Tools and Applications* 79, no. 19 (2020): 14031-14051.
- [56].SREENIVAS, MEKALA. "A novel document representation approach for authorship attribution." *International Journal of Intelligent Engineering and Systems* (2018).
- [57].Vidhya Prasanth, Sathiyaraj Chinnasamy, M. Ramachandran, Chinnasami Sivaji, "Assessment of Pyrolysis Material Selection Using WPM as an Auxiliary Tool" *Building Materials and Engineering Structures*,1(4), December 2023, 35-40
- [58].Kouchaksaraei, Ramtin Haghazar, Sarfaraz Hashemkhani Zolfani, and Mahmood Golabchi. "Glasshouse locating based on SWARA-COPRAS approach." *International Journal of Strategic Property Management* 19, no. 2 (2015): 111-122.
- [59].Naycemuddin, M. Ramachandran, Chinnasami Sivaji, and Prabakaran Nanjundan. "A Study on Renewable Energy and Wind Power." *REST Journal on Advances in Mechanical Engineering* 1, no. 2 (2022): 10-18.
- [60].Bogireddy, Srinivasa Rao, and Haritha Murari. "Machine learning for predictive telemarketing: Boosting campaign effectiveness in banking." In *2024 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)*, pp. 1-6. IEEE, 2024.
- [61].Manikandan, M. G., and G. Bhuvanewari. "Measuring the Influence of Artificial Intelligence (AI) on Online Purchase Decisions-In Case of Indian Consumers." *International Journal of Scientific Research in Science Engineering and Technology* 11, no. 1 (2024).
- [62].Kumar, KRN Kiran, K. Bhavani, and D. Narahari. "Identification of Fraud Detection in Credit Card using Majority Voting and ADA Boost Classification Methods in Data Mining."
- [63].Chinnasami Sivaji, Krishnan Chinnasamy, M. Ramachandran, Ramya sharma, "Evaluating the Suitable Material Used in Small Wind Turbine Blades Using the GRA Method", *REST Journal on Emerging trends in Modelling and Manufacturing*, 9(4) December 2023, 28-35.