IJIRIS: International Journal of Innovative Research in Information Security
Volume 11, Issue 11, November 2025
E-ISSN: 2349-7017
P-ISSN: 2349-7009
https://www.ijiris.com/archives
https://doi.org/10.26562/ijiris.2025.v1111.08

Design and Fabrication of Unmanned Ground Vehicle

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Publication History
Manuscript Reference No: IJIRIS/RS/Vol.11/Issue11/NVISXI10087
Research Article Open Access| Double-Blind Peer-Reviewed| Article ID: IJIRIS/RS/Vol.11/Issue11/NVISXI10087 Received: 28, October 2025, Revised: 05, November 2025, Accepted: 12, November 2025, Published Online: 21, November 2025.
https://www.ijiris.com/volumes/Vol11/iss-11/08.NVISXI10087.pdf
Citation: Vijay,Yogananda,Madan,Sanjay,Monish,Vaibhav(2025),Design and Fabrication of Unmanned Ground Vehicle, ,IJIRIS: International Journal of Innovative Research in Information Security, Volume 11, Issue 11 of 2025 pages 772-774
Doi:> https://doi.org/10.26562/ijiris.2025.v1111.08
BibTeX Key: Vijay@Design
IJIRIS papers should be cited as IJIRIS (International Journal of Innovative Research in Information Security, AM Publications, India 2025, ISSN 2349-7017, https://doi.org/10.26562/ijiris.2025.v1111.08 The journal's official abbreviation is IJIRIS. Orcid: https://orcid.org/0009-0004-9398-7488

Abstract: This paper presents the design and fabrication of a multifunctional Unmanned Ground Vehicle (UGV) intended for high-risk and labour-intensive environments in military, agricultural, construction, and surveying sectors. The vehicle integrates a mild steel chassis, geared DC motors, a Honda GX160 engine, RF based remote control, and modular payload provisions to support goods transport, reconnaissance, and field operations over rough terrain. A transmission control system enhances terrain adaptability and load handling, while the overall architecture emphasizes modularity, remote operation, and future upgradability with advanced sensing and autonomy.
Keywords: Unmanned Ground Vehicle (UGV), Multifunctional design, High-risk environments, Labour-intensive sectors, surveying sectors, Remote operation, Modularity.

INTRODUCTION

Unmanned Ground Vehicles are increasingly deployed in hazardous or inaccessible environments to reduce human exposure and improve operational efficiency. In India and globally, UGVs are emerging in military logistics, precision agriculture, and construction sites where continuous operation, all terrain mobility, and reliable teleportation are essential. The work reported here focuses on a multipurpose UGV designed primarily as a goods carrier capable of traversing uneven terrain while supporting sector specific attachments such as surveillance sensors or agricultural implements. The project aligns with Sustainable Development Goal (SDG) 9 by promoting technological innovation, resilient infrastructure, and safer, more efficient industrial practices.

LITERATURE REVIEW

Recent studies report the growing role of UGVs in defence applications such as reconnaissance, explosive ordnance disposal, and logistics support, highlighting the need for robust driveline and steering systems in complex terrains. Other works emphasize resilience analysis, fault tolerant architectures, and operator trust, indicating that reliability and human robot interaction are critical for field deployment. In agriculture, surveys document UGV use for soil sampling, irrigation management, crop monitoring, and transport of goods, showing improved precision and reduced labour requirements.

- Defence UGVs: manoeuvrability, resilience, driveline/steering, operator attitude.
- Agricultural/environmental UGVs: crop monitoring, soil sampling, goods transport.
- Construction UGVs: material transport, site inspection, reliability/fault tolerance.

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- Key enabling technologies: sensors (LiDAR, vision, IMU), control methods (MPC, adaptive/robust) and gaps that your design addresses.

Objectives

The objectives of your UGV project are:

- Develop a versatile, durable UGV for military, agriculture, and construction use.
- Ensure safe remote operations in hazardous and rough terrain environments.
- Integrate robust transmission and control for efficient mobility.
- Design a modular chassis for adaptable payloads and sensors.
- Support precision tasks like reconnaissance, material transport, and surveying.
- Provide a cost-effective platform aligned with sustainable development goals.
- Lay foundation for future autonomous and swarm capabilities.

METHODOLOGY

The project methodology consists of the following steps:

A. Problem Identification: Understanding the daily challenges faced by vendors such as fatigue, limited mobility, and low operating range.

B. Conceptual Design: Sketches and 3D modelling using AutoCAD were performed to finalize dimensions, weight distribution, wheelbase, and ergonomics.

C. Material and Component Selection: Selection was based on structural strength, cost, availability, and energy efficiency.

D. Design Analysis: Structural loads, stability analysis, factor of safety, torsional rigidity, and battery sizing were calculated.

E. Fabrication: Includes cutting, welding, grinding, assembling, wiring, painting, and testing.

F. Performance Testing: Measured speed, load capacity, battery discharge rate, motor temperature, and terrain adaptability.

MECHANICAL DESIGN

A. Chassis and Frame

- Mild-steel tube frame dimensions, rationale (strength, load, manufacturability).
- Mounting points for engine, motors, suspension/bearings, payload.

B. Mobility and Drivetrain

- Four-wheel configuration, 16-inch off-road tyres, shafts, bearings, plumber blocks.
- Engine (e.g., Honda GX160), geared DC motors, sprocket-chain transmission, speed/torque targets.

C. Braking and Safety

- Disc brakes, placement, stopping capability on slopes.
- Structural safety factors, weld quality and protective coating.

Calculations

A. Load Capacity Calculation

Total load = Frame weight +Wheels and Shaft +Engine + Material load.

$$TL = 55kg+25kg+12kg+100kg=192kg \text{ approximately}$$

B. Power Calculation

The Honda GX160 engine produces 5.5 HP (4.1 kW) at 3600 RPM.

Let's assume a mechanical efficiency of 0.8 (80%). Power output: 4.1 kW x 0.8 = 3.28 kW

C. Speed Calculation

To estimate the vehicle's top speed, we'll need to know the gear ratio, wheel diameter, and rolling resistance. Let's assume: Wheel diameter: 0.4m (16 inches) , Gear ratio: 1:1 (direct drive) Centrifugal Clutch, Rolling resistance coefficient: 0.05 (rough estimate) : $Fr=\mu\times m\times g=0.05\times 95\times 9.81=46.55N$, Top speed calculation: approximately 20-30 km/h (depending on gear ratio and terrain)

D. Torque Calculation

Engine torque: 11.5 Nm (Honda GX160 specs) , Gear ratio: assume 1:1 (direct drive) , Wheel torque: $T=Fr\times r=46.55\times 0.2=9.31Nm$ (assuming direct drive)

E. Stability and Balance

Center of gravity: approximately 0.35m (half of 0.7m height)

F. Chassis Strength Analysis

Stress = Force / Area; FoS ≥ 2 for safety.

FABRICATION PROCESS

The fabrication process began with CAD based modelling of the UGV chassis and wheel geometry, followed by selection of mild steel tubes and aluminium sheet for structural and body components. Tubes were cut to dimension, tack welded, and then fully welded using ARC processes, after which grinding and protective coating were applied to improve durability and corrosion resistance. Wheel assemblies were mounted at the four corners using shafts, bearings, and plumber blocks, and the drive train (engine, sprockets, chains, and geared DC motors) was installed to achieve the desired speed–torque characteristics.

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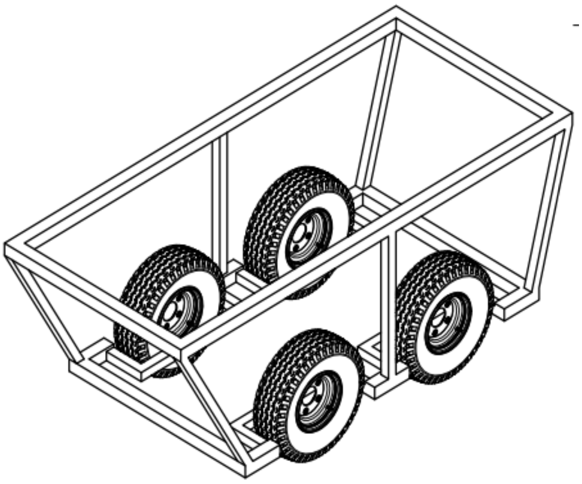
- Wiring Integration: Controller, throttle, switches.
- Wheel Mounting: Fixing wheels with bearings.
- Painting: Applying antirust coating.
- Testing: Conducting trial runs.

RESULTS AND DISCUSSION

Prototype tests indicate that the UGV can transport loads over rough ground while maintaining stability due to its low center of gravity, wide track, and off-road tyres. Disc brakes and structural robustness support safe operation on slopes and under impact loads, while the modular frame allows rapid reconfiguration for different missions. From an ergonomic perspective, using familiar joystick or gamepad style interfaces and providing feedback to the operator simplifies teleportation and reduces cognitive load during extended missions. The current platform demonstrates good mechanical performance but relies heavily on the operator for navigation, suggesting that future integration of autonomous navigation, richer sensor suites, and more advanced control algorithms would significantly increase capability.

Challenges Identified:



Design model **Fabricated model**

CONCLUSION AND FUTURE WORK

The project successfully demonstrates the design and fabrication of a multipurpose UGV capable of goods transport and adaptable to military, agricultural, construction, and surveying tasks through modular payloads and a robust transmission system. The mild steel chassis, off-road wheel configuration, and RF Based control architecture provide a practical, low-cost platform for real-world field operations and academic research. Future work will focus on integrating advanced sensing (LiDAR, vision, GPS), closed-loop control, and higher levels of autonomy for path planning, obstacle avoidance, and swarm coordination. Additional directions include optimizing weight through alternative materials, implementing comprehensive battery and energy management, and validating performance through extended field trials in representative military, agricultural, and construction scenarios.

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