# Project Report: Shape-Shifting Rover

https://www.youtube.com/shorts/egiBT4q2O5E

### 1. Purpose

The purpose of this project is to design and develop a low-cost, bio-inspired **Shape-Shifting Rover** that can adapt its body configuration to navigate different terrains. Unlike traditional rovers with fixed chassis, this rover can reconfigure itself to operate as a wheeled rover, crawler, or snake-like robot depending on the environment. This adaptability makes it suitable for exploration, disaster rescue, and research applications.

### 2. Introduction

Robots are typically designed for specific terrains, limiting their ability to adapt when conditions change. For example, wheeled robots are efficient on flat ground but struggle on rough or narrow pathways. Inspired by nature, where animals adapt their gaits and body shapes for survival, the Shape-Shifting Rover is a novel design that incorporates modular mobility. By integrating hinged chassis segments, transformable wheels, and autonomous terrain sensing, the rover can switch between multiple locomotion modes. This project demonstrates an affordable yet innovative approach to terrain-adaptive robotics with potential applications in search and rescue, space exploration, and hazardous environment monitoring.

### 3. Bill of Materials (BOM)

| Component | Quantity | Approx. Cost (USD) |
|---|---|---|
| Arduino Mega / ESP32 (control board) | 1 | $20 |
| Servo motors (high-torque, for chassis transformation) | 8 | $60 |
| DC gear motors with encoders (for wheels) | 4 | $40 |
| Motor driver module (L298N / Cytron) | 1 | $15 |
| Hinged aluminum / 3D-printed frame | – | $40 |
| LiPo battery pack + charger | 1 | $35 |
| Ultrasonic sensors | 3 | $10 |
| IMU (Gyroscope + Accelerometer) | 1 | $15 |
| Camera module (ESP32-CAM or Pi Cam) | 1 | $15 |

| Component | Quantity | Approx. Cost (USD) |
| --- | --- | --- |
| Wheels & mechanical accessories | – | $25 |
| Miscellaneous (wires, connectors, fasteners) | – | $20 |

**Total Estimated Cost: $295**

**4. Procedure**

1. **Frame Construction**: Design and fabricate the modular chassis with hinged joints to allow articulation.
2. **Motor Integration**: Attach DC motors for locomotion and servo motors at hinge points for transformation.
3. **Electronics Setup**: Mount the control board, motor drivers, sensors, and camera module.
4. **Programming**:
   - Mode 1: Standard 4-wheel drive for flat surfaces.
   - Mode 2: Crawler mode (hinges open, wheels rotate differently).
   - Mode 3: Snake-like undulation using servos for narrow or rough terrains.
5. **Sensor Integration**: Use ultrasonic sensors and IMU to detect terrain type and trigger reconfiguration.
6. **Testing**: Conduct trials on sand, gravel, slopes, and confined pathways to evaluate shape-shifting effectiveness.

**5. Expected Outcome**

The Shape-Shifting Rover is expected to successfully demonstrate multi-terrain adaptability by switching between rover, crawler, and snake-like modes. This will provide enhanced mobility, resilience, and efficiency compared to fixed-design robots. The project contributes to bio-inspired robotics research, offering a low-cost prototype that can inspire further development in search and rescue missions, exploration robotics, and environmental monitoring.

**6. Limitations**

1. **Mechanical Complexity** – The articulated chassis and multiple servo joints increase chances of mechanical failure or misalignment.

2. **Power Consumption** – Servos and motors operating simultaneously drain the battery quickly, limiting mission time.
3. **Weight vs. Strength Trade-off** – Using lightweight materials for shape-shifting may reduce durability, while heavier materials reduce mobility.
4. **Control Challenges** – Coordinating multiple locomotion modes (rover, crawler, snake) requires advanced coding and precise sensor feedback.
5. **Stability Issues** – Rapid reconfiguration during movement may cause imbalance or tipping on uneven terrain.
6. **Sensor Dependency** – Accurate terrain detection depends heavily on sensors (IMU, ultrasonic), which may not always function reliably outdoors.
7. **Prototype Scaling** – While feasible as a prototype, scaling the design for real-world exploration would require stronger actuators and more robust materials, increasing cost.