Design and Development of a Reliable Dual Recovery System with Extended Range Telemetry for the Nakuja N4 Rocket

Glenn Kanyi – ENM221-0149/2021
Ian Joseph – ENM221-0249/2021

Emails: glenngatiba@gmail.com, josephian1810@gmail.com
Contacts: 0705 589 973 / 0768 395 187

September 23, 2025

1. Problem Statement

The Nakuja N4 rocket's current parachute deployment mechanism uses nichrome wire to burn through retaining cords. However, it can be harmful to parachute deployment because the nichrome wire frequently heats up too quickly and may melt before achieving dependable ignition. The telemetry range of the current avionics is restricted, resulting in communication blackouts during recovery operations. The mission's success and payload recovery are seriously jeopardized by these two issues.

2. Objectives

The main objective is to design and prototype an **improved dual recovery system** with extended telemetry range for the N4 rocket.

Specific Objectives:

1. To design a **redundant parachute deployment system** that ensures safe ejection even if one mechanism fails.
2. To replace or improve the nichrome ignition method with a **more reliable heating and ejection system**.
3. To integrate **XBee-based long-range telemetry** into the avionics system and fabricate custom PCBs for compact integration.

4. To conduct **pop tests** for deployment reliability and **range tests** for telemetry validation.

5. To simulate and evaluate the **weight distribution** of the avionics bay to ensure the center of gravity (CoG) remains balanced.

3. Justification

- Enhances **mission safety and recovery success** by preventing premature or failed parachute deployment.
- Extends telemetry coverage, reducing the risk of data loss and improving tracking during recovery.
- Demonstrates **mechatronic system integration** combining mechanical design, electronics, software, and testing.
- Builds local capacity in designing low-cost, reliable avionics for rocketry in Kenya.

4. Methodology

The methodology is structured as a **mechatronics system**, comprising mechanical, electrical, and software & control subsystems:

4.1 Mechanical

- Design and fabricate the **dual deployment bay** for housing main and drogue parachutes.
- Develop improved **ignition housings** to prevent premature melting of nichrome wires.
- Simulate and test the **weight balancing of the avionics bay** to ensure CoG alignment with the rocket body.

4.2 Electrical

- Integrate **XBee modules** for long-range telemetry communication.
- Design and fabricate **custom PCBs** to integrate the avionics (microcontroller, XBee, deployment circuits).
- Implement redundant ejection circuits to support **dual recovery**.

4.3 Software and Control

- Implement control algorithms for **safe parachute ejection sequencing**.
- Develop telemetry handling software for **real-time range data transmission**.
- Interface microcontroller code with XBee and deployment drivers.

5. Testing and Validation

1. **Pop Tests:** Conduct repeated ground tests of the parachute ejection system to validate ignition reliability and redundancy.
2. **Range Tests:** Measure the effective communication distance of the XBee-based telemetry system in open fields.
3. **Weight Balancing Tests:** Simulate avionics bay assembly to confirm CoG is within acceptable rocket stability limits.

6. Expected Outcomes

- A reliable **dual parachute deployment system** with redundant ignition.
- Extended **telemetry range** using integrated XBee communication.
- A tested and validated avionics PCB suitable for flight integration.
- Documentation of tests and design iterations.

7. References

1. XBee Datasheet and Communication Range Documentation.
2. Research on Reliable Parachute Deployment Systems in High-Power Rocketry.
3. Nakuja Project Archive – Previous Avionics and Recovery Designs.