ASEC 2025 Conference
The 6th International Electronic Conference on Applied Sciences
09–11 December 2025 | Online
MDPI

# Altitude Control in an Unmanned Aerial Vehicle Through Deflection of Elevator

**Muhammad Hashier Muneeb Farrukh, Dr. Syed Irtiza Ali Shah, Ibtesam Hayat, Hafiz Usama Tanveer, Rai Faisal Aslam, Hasham Tanveer**
**St. Cloud State University, National University of Science and Technology, Air University, George Mason University, St. Cloud State University, Drexel University**

## RESEARCH OBJECTIVE

Development of an efficient altitude control system for unmanned aerial vehicles through precise elevator deflection mechanisms using control engineering principles.

## PROBLEM STATEMENT

- Controlling vertical height using elevator control input
- Maintaining stability during altitude transitions
- Achieving precise altitude tracking with minimal error
- Optimized PID controller design for altitude stabilization
- Comprehensive stability analysis through control theory

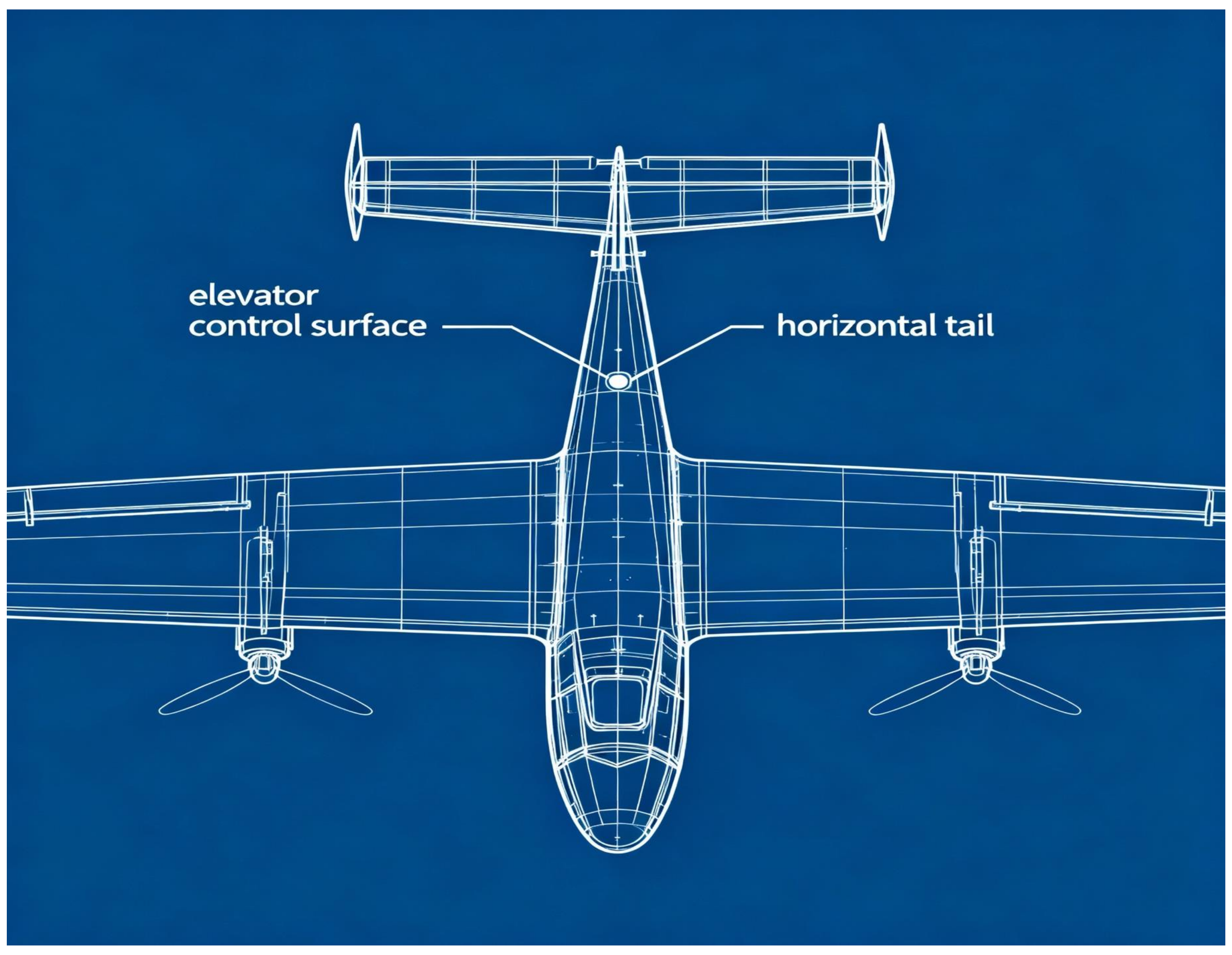
## ELEVATOR CONTROL MECHANISM

### Flight Control Surfaces:

- **Elevators:** Primary flight control surfaces located on the horizontal tail
- **Function:** Control aircraft pitch attitude and angle of attack
- **Mechanism:** Deflection changes airflow over tail surface
- **Effect:** Alters lift distribution and vertical flight path

### Control Distinction:

- **Elevator:** Movable control surface for pitch control
- **Stabilizer:** Fixed horizontal surface for stability




*Fixed-wing UAV with elevator control surfaces*

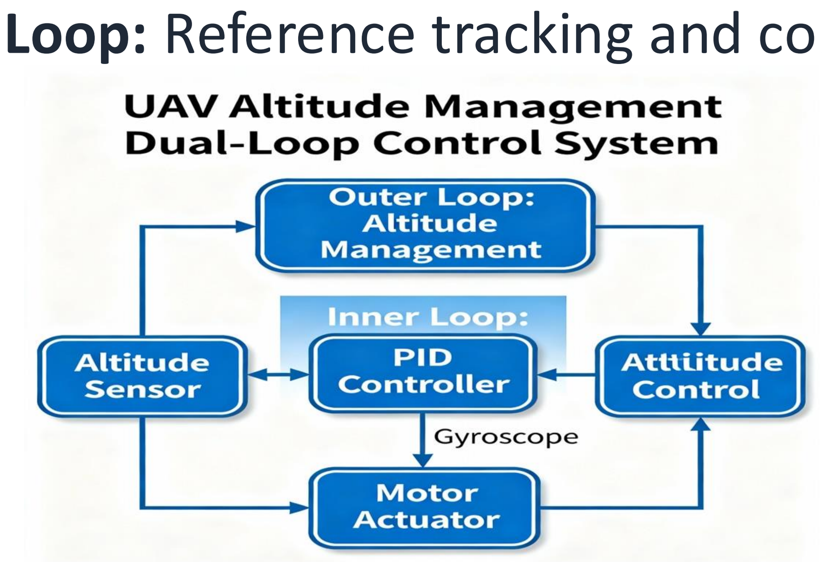
## CONTROL SYSTEM ARCHITECTURE

### Piloting Methods:

- **Ground Simulation:** Remote pilot control with ground station
- **Onboard Control:** Autonomous flight management systems

### Dual-Loop Control System:

- **Inner Loop:** Stability augmentation and robustness enhancement
- **Outer Loop:** Reference tracking and command following




*Dual-loop control architecture for UAV altitude management*

## CONTROL STRATEGIES FOR UAV SYSTEMS

| Control Method | Primary Application | Key Advantage | Limitation |
|---|---|---|---|
| GPS-based Control | Navigation & Positioning | Real-time positioning accuracy | Signal dependency and interference |
| Neural Network Control | Complex Non-linear Systems | Learning and adaptation capability | High computational intensity |
| Adaptive Control | Parameter Uncertainty | Adaptive to system changes | Implementation complexity |
| PID Controller | Altitude Stabilization | Simple and highly effective | Fixed parameter tuning |

## STEP RESPONSE ANALYSIS

### Without PID Controller:

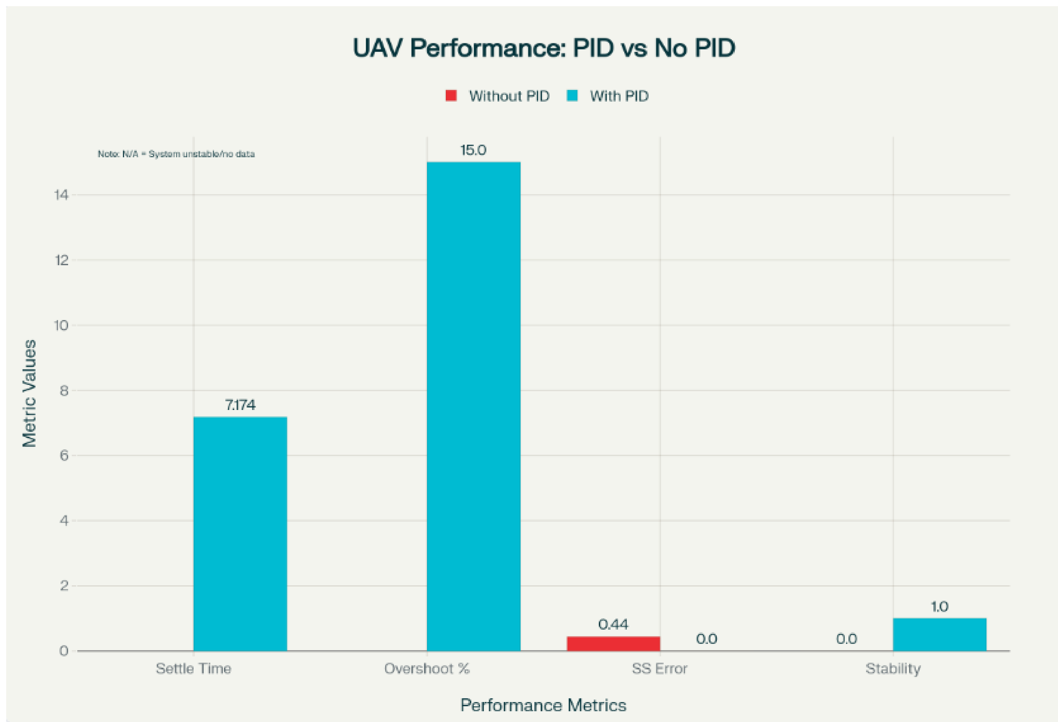
- Unstable response
- Infinite settling time
- Unbounded overshoot
- Poor disturbance rejection

### With PID Controller:

- Stable response achieved
- Settling time: 7.174 seconds
- Controlled overshoot: 15%
- Excellent tracking performance

### Key Performance Improvements:

- **Stability Achievement:** System becomes stable and controllable
- **Minimal Steady-state Error:** Approaching zero for step inputs
- **Fast Response:** Settling within acceptable time frame
- **Robust Performance:** Consistent behavior across operating conditions




*Performance comparison: With and without PID controller*

## CONCLUSION

The PID controller implementation successfully stabilizes the UAV altitude control system, transforming an inherently unstable system into a robust and well-performing control system. The controller achieves zero steady-state error for step inputs, maintains stability with finite error for ramp inputs, and demonstrates excellent transient response characteristics with settling time of 7.174 seconds and overshoot of 15%.

CONTACT: Muhammad Hashier Muneeb Farrukh (hashir.m36@zoho.com)