# Design Requirements

**Customer Requirements:**

- CR1 -  High Mobility – highly maneuverable
- CR2 – Small dimensions and still fit all essential components
- CR3 –  Complete Recon Mission
- CR4 – Payload Capacity – carry a significantly heavy payload
- CR5 – Battery Capacity – efficient/large enough
- CR6 – Cost  Efficiency – limited budget
- CR7 – Thrust Efficiency – high thrust to weight ratio

**Engineering Requirements:**

- ER1 – Thrust to weight Ratio – goal of 3:1
- ER2 – Compact design – 5x5x5 ft, under 50 lbs.
- ER3 – Payload Weight – 30% of total weight
- ER4 – Time of Flight – 10 minutes or more
- ER5 – Total Cost – 3300$ budget
- ER6 – Meet FAA regulations – under 55lbs, fly under 400 ft

# Top Level Testing

| Experiment/Test | Relevant DRs | Testing Equipment Required | Other Resources |
|---|---|---|---|
| Exp 1: Take-off Test | ER – 4<br>ER – 6<br>CR – 3<br>CR – 5 | -Drone System<br>-FlySky Remote<br>-Recording Device (iPhone)<br>-stopwatch | -Good weather or large indoor location<br>-certified drone pilot<br>-Level Ground |
| Exp 2: Landing | ER – 4<br>ER – 6<br>CR – 3<br>CR – 5 | -Drone System<br>-FlySky Remote<br>-Recording Device (iPhone)<br>-stopwatch | -Good weather or large indoor location<br>-certified drone pilot<br>-level ground |
| Exp 3: Thrust Dyno Testing | ER – 1<br>CR – 7 | -Strain gauge test stand/dynamometer<br>-Motor + propeller<br>-Digital multimeter | -excel spreadsheet<br>-Ear Protection<br>-Eye Protection<br>-Video Camera |
| Exp 4: Side-to-side mobility test | ER – 2<br>CR – 1<br>CR – 2 | -Drone System<br>-FlySky Remote<br>-Recording Device (iPhone) | -Good weather or large indoor location<br>-certified drone pilot |
| Exp 5: Payload pickup and deployment | ER – 3<br>CR – 4 | -Drone System<br>-FlySky Remote | -weighted payload (hand weight)<br>-camera payload |

# Testing Plan

**Flight & Thrust Tests**
- **Main Objective:**
  - Determine if the drone can lift off with its intended payload
  - "Will it go up?" – baseline flight readiness
- **Testing Focus:**
  - Static thrust testing using custom thrust test stand
  - Payload lift reliability and consistency
- **Test Stand Setup:**
  - Motor mounted on linear rail
  - 10 kg load cell for thrust measurement
  - Arduino + ESC for throttle control
  - Powered by LiPo battery
  - Data collected: thrust (g), current draw(A)
- **Pass Criteria:**
  - Thrust output ≥ total weight (drone + payload)
  - Reliable, repeatable lift force across test runs

**Magnetic Payload Engagement**
- **Purpose:**
  - Test reliability of magnet-based payload attachment and release
- **Engagement Method:**
  - Electromagnet or magnetic latch triggered onboard switch
  - Engage during takeoff, release on landing
- **Testing Focus:**
  - Confirm payload stays securely attached during lift
  - Test repeatability of magnetic engagement and release
  - Observe any shifts or instability during hover and movement
- **Pass Criteria:**
  - Payload remains attached during full-thrust lift
  - Clean and controlled disengagement when triggered

# Testing Results

## Thrust Dynamometer Testing (3)

| 16x8 Propeller | | |
|---|---|---|
| Percent Thrust (%) | Average Thrust (g) | Average Current (A) |
| 0 | 0 | 0.31 |
| 15 | 339 | 3.65 |
| 30 | 2714 | 12.5 |
| 45 | 5647 | 29.89 |
| 60 | 6779 | 54.61 |

## Flight Tests (1,2,4)

**Issue:**
Two diagonal motors overheated and one failed during flight testing.

**Cause:**
Misconfigured motor directions in the flight controller caused the CW motors to overcompensate, leading to overheating.

**Fix:**
- Corrected motor rotation settings in software
- Verified direction and prop orientation
- Replaced damaged motor and retested successfully

## Payload Deployment (5)

- **Payload Deployment System – Success**
- Magnetic switch system fully integrated and operational
- Payload deploys reliably on command
- Simple, lightweight mechanism with no mechanical failures observed

# Testing Demonstration

# Spec Sheet

| Engineering Requirement | Target | Tolerance | Measured/ Calculated Value | ER met? | Client Acceptable |
|---|---|---|---|---|---|
| ER1 - Thrust to Weight Ratio | 3:1 | +/- 100 g | | | |
| ER2 - Compact Design | 5X5X5 ft / <50 lbs | 1 in/ 5lbs | 4x4x4 ft / 23.6 lbs | Yes | Yes |
| ER3 - Complete Course in Time Limit | 9 minutes | +/- 1 minute | | | |
| ER4 - Payload Weight | 30% weight of the system | +/- 1 pound | 6.9 lbs | Yes | Yes |
| ER5 - Time of Flight | 10 minutes | +/- 30 seconds | | | |
| ER6 - Total Cost | $3000 | +/- $717.70 | $3,434.61 | Yes | Yes |
| ER7 - Meet FAA Requirements | Met | N/a | N/a | Yes | Yes |

| Customer Requirement | CR met? | Client Acceptable |
|---|---|---|
| CR1 - High Mobility | TBD | TBD |
| CR2 - Small | Yes | Yes |
| CR3 - Complete Recon Mission | TBD | TBD |
| CR4 - Payload Weight | Yes | Yes |
| CR5 - Battery Capacity | TBD | TBD |
| CR6 - Cost Efficiency | Yes | Yes |
| CR7 - Thrust Efficiency | Yes | Yes |

# QFD



**Correlation Matrix (3 Highest on scale)**

| Technical Requirement | Thrust:weight > 3:1 | Compact Design under 3'x3'x3' | Complete Course < 10 min | Payload > 30% of weight | Time of flight > 10 min | Total Cost under $3,000 | Meets FAA requirements (weight < 55 lbs) |
|---|---|---|---|---|---|---|---|
| Thrust : weight > 3:1 | | | | | | | |
| Compact Design under 3'x3'x3' | | | | | | | |
| Complete Course < 10 min | 3 | | | | | | |
| Payload > 30% of weight | 1 | 1 | | | | | |
| Time of flight > 10 min | 3 | 1 | 1 | | | | |
| Total Cost under $3,000 | | 3 | | | 1 | | |
| Meets FAA requirements (weight < 55 lbs) | 3 | 3 | | 1 | 3 | 3 | |

**Technical Requirements**

| Customer Needs | Customer Weights: 1-5 | Thrust : weight > 3:1 | Compact Design under 3'x3'x3' | Complete Course < 10 min | Payload > 30% of weight | Time of flight > 10 min | Total Cost under $3,000 | Meets FAA requirements (weight < 55 lbs) |
|---|---|---|---|---|---|---|---|---|
| High mobility | 4 | 5 | 5 | 5 | 1 | 2 | 1 | |
| Small | 1 | 4 | 5 | 3 | | 5 | 5 | 5 |
| Complete Boeing Recon Mission | 5 | 5 | 3 | 2 | 4 | 2 | | |
| Payload Capacity | 5 | 5 | 1 | 2 | 5 | 1 | 2 | |
| Battery Capacity for small mission | 4 | 3 | 2 | 4 | 4 | 5 | 1 | 1 |
| Cost Efficiency | 3 | 1 | 2 | 3 | | 2 | 5 | 4 |
| Thrust Efficiency | 4 | 5 | 3 | 5 | 4 | 5 | 2 | |
| Technical Requirement Units | | | Feet | minutes | % weight | minutes | USD | pounds |
| Technical Requirement Targets | | 3:1 | < 3x3x3 | < 10 | > 30 | > 10 | >3000 | < 55 |
| Absolute Technical Importance | | 28 | 24 | 24 | 18 | 22 | 16 | 15 |
| Relative Technical Importance | | 1 | 3 | 3 | 5 | 4 | 6 | 7 |

# Questions?