1. **Total System Power Requirement**

A. ELECTRICAL LOADS

Component	Voltage	Max Current (A)	Power (W)
2 × T100 Thrusters	12.8V	11.5 × 2 = 23	294.4
Raspberry Pi 3B	5V	2.5	12.5
ESP32	5V	0.24	1.2
RPLIDAR A1M8	5V	0.45	2.25
SG92R Servo	5V	2.0	10.0
GNSS Module	5V	0.04	0.2
Ultrasonic Sensors	5V	0.06	0.3
Telemetry Radio	5V	0.1	0.5
Misc. Sensors (IMU, etc.)	5V	0.1	0.5
Total 5V Load		5.89A	27.45W

- 5V load converted to 12.8V (85% efficiency):

$$\frac{27.45\text{W}}{0.85} = 32.3\text{W}$$

$$\frac{32.3\text{W}}{12.8\text{V}} = 25.2\text{A at } 12.8\text{ V}$$

System Section	Voltage	Current (A)	Power (W)
Thrusters	12.8V	23	294.4
5V Electronics (to 12.8V)	12.8V	2.52	32.3
Total	12.8V	25.52	326.7

B. MECHANICAL/NAVAL & ENVIRONMENTAL MARGINS

- Mechanical/propulsion inefficiency, environmental factors, maneuvering, and real-world losses:
  Add 25% margin to cover these factors.
- Adjusted Total Power**:**

$$326.7\text{ W} \times 1.25 = 408.4\text{W}$$

2. **Battery Sizing Calculation**

A. USABLE BATTERY CAPACITY

- LiFePO4 batteries are best used at 80% Depth of Discharge (DoD) for long life.
- 30Ah battery at 12.8V:

$$12.8\text{ V} \times 30\text{ Ah} = 384\text{Wh (total)}$$
$$384\text{ Wh} \times 0.8 = 307.2\text{Wh (usable)}$$

B. RUNTIME CALCULATION

- At full load (408.4W):

$$\text{Runtime} = \frac{307.2\text{ Wh}}{408.4\text{ W}} = 0.75\text{ hours} \approx 45\text{ minutes}$$

- At half load (more typical, e.g., 200W):

$$\text{Runtime} = \frac{307.2\ \text{Wh}}{200\ \text{W}} = 1.54\ \text{hours} \approx 1\ \text{hour}\ 32\ \text{minutes}$$

3. Battery Specification Recommendation

Parameter	Requirement
Chemistry	LiFePO4
Nominal Voltage	12.8V
Minimum Capacity (for 1 hr)	40Ah (for 1 hr at full load)
Minimum Capacity (for 2 hr)	80Ah (for 2 hr at full load)
Continuous Discharge Current	≥26A (matches max system load)
Depth of Discharge (DoD)	80% (for long cycle life)
Integrated BMS	Yes (over/under voltage, overcurrent)
Cycle Life	2000–5000 cycles at 80% DoD

4. Example Calculation for Battery Size

If you want at least 1 hour at full load (408.4W, 80% DoD):

- Required usable energy: 408.4Wh
- Required total battery energy:

$$\frac{408.4\ \text{Wh}}{0.8} = 510.5\ \text{Wh}$$

- Required capacity at 12.8V:

$$\frac{510.5\ \text{Wh}}{12.8\ \text{V}} = 39.9\ \text{Ah} \rightarrow 40\text{Ah minimum}$$