DETAILED POWER CONSUMPTION ANALYSIS

1. BATTERY SPECIFICATIONS

11.1V 2200mAh LiPo Battery

- **Nominal Voltage**: 11.1V (3S LiPo)
- **Capacity**: 2200mAh = 2.2Ah
- **Energy Storage**: 11.1V × 2.2Ah = **24.42 Wh**
- **Usable Capacity**: ~85% (to prevent deep discharge) = **20.76 Wh**
- **Voltage Range**: 12.6V (full) to 9.6V (empty)

2. COMPONENT-BY-COMPONENT POWER ANALYSIS

A. Arduino UNO R4 WiFi (Renesas RA4M1)

Mode	Current Draw	Power @ 12V
Idle	25mA	0.30W
Processing	45mA	0.54W
WiFi Active	80mA	0.96W
Typical Running	**50mA**	**0.60W**

B. L298N Motor Driver + DC Motor

Condition	Current Draw	Power @ 12V
Driver Quiescent	35mA	0.42W
Motor Idle	50mA	0.60W
Motor Running (50% PWM)	400mA	4.80W
Motor Turning	600mA	7.20W
Motor Stalled	1200mA	14.40W
Average Navigation	**450mA**	**5.40W**

C. Servo Motor SG90 (via LM2596)

State	Current @ 5V	Power @ 5V	Power @ 12V*
Idle	10mA	0.05W	0.06W
Moving	250mA	1.25W	1.47W
Holding Position	100mA	0.50W	0.59W
Average Use	**120mA**	**0.60W**	**0.71W**

D. HC-SR04 Ultrasonic Sensors (×3)

State	Current Each	Total (×3)	Power @ 5V
Idle	2mA	6mA	0.03W
Measuring	15mA	45mA	0.225W
Average	**10mA**	**30mA**	**0.15W**

E. Pixy2 Camera (CMUcam5)

Mode	Current @ 5V	Power @ 5V
Idle	60mA	0.30W
Tracking	140mA	0.70W
LED On	180mA	0.90W
Typical	**140mA**	**0.70W**

F. LM2596 Step-Down Regulator

Parameter	Value
Efficiency	85%
Quiescent Current	5mA
Self Power Loss	0.06W
Total Overhead	**15% of 5V load**

G. System Overhead

Component	Current	Power
Pull-up Resistor	0.5mA	0.0025W
Wiring Losses	~2%	~0.15W
Total	**~13mA**	**~0.15W**

3. POWER DISTRIBUTION SUMMARY

12V Rail (Direct from Battery)

Component	Current	Power
Arduino R4 WiFi	50mA	0.60W
L298N + Motor	450mA	5.40W
LM2596 Input*	83mA	1.00W
Total 12V Rail	**583mA**	**7.00W**

5V Rail (From Arduino)

Component	Current	Power
3× HC-SR04	30mA	0.15W
Pixy2 Camera	140mA	0.70W
Pull-up	0.5mA	0.0025W
Total 5V Arduino	**170.5mA**	**0.85W**

5V Rail (From LM2596)

Component	Current	Power
Servo SG90	120mA	0.60W

4. OPERATING SCENARIOS

Scenario 1: Straight Line Navigation

```
Arduino:          50mA × 12V = 0.60W
Motor (40% PWM): 350mA × 12V = 4.20W
Servo (center):   50mA × 5V = 0.25W (0.29W @ 12V)
Sensors:          30mA × 5V = 0.15W
Pixy2:           140mA × 5V = 0.70W
Overhead:                     0.15W
---------------------------------------
TOTAL:           ~480mA @ 12V = 6.19W
```

Scenario 2: Turning Maneuvers

```
Arduino:          50mA × 12V = 0.60W
Motor (60% PWM): 550mA × 12V = 6.60W
Servo (turning): 250mA × 5V = 1.25W (1.47W @ 12V)
Sensors:          45mA × 5V = 0.225W
Pixy2:           140mA × 5V = 0.70W
Overhead:                     0.20W
---------------------------------------
TOTAL:           ~750mA @ 12V = 9.58W
```

Scenario 3: Obstacle Detection & Processing

```
Arduino (peak):   70mA × 12V = 0.84W
Motor (stop):     50mA × 12V = 0.60W
Servo (active):  150mA × 5V = 0.75W (0.88W @ 12V)
Sensors (all):    45mA × 5V = 0.225W
Pixy2 (LED on):  180mA × 5V = 0.90W
Overhead:                     0.15W
---------------------------------------
TOTAL:           ~380mA @ 12V = 4.56W
```

5. BATTERY LIFE CALCULATIONS

Average Power Consumption Profile

Assuming typical maze navigation:

- 60% straight navigation: 6.19W
- 30% turning: 9.58W
- 10% obstacle processing: 4.56W

Weighted Average: (0.6 × 6.19) + (0.3 × 9.58) + (0.1 × 4.56) = **7.05W**

Battery Runtime Calculations

Usable Energy: 20.76 Wh (85% of 24.42 Wh)

Average Power: 7.05W

Runtime = 20.76 Wh ÷ 7.05W = 2.94 hours

6. PEAK CURRENT ANALYSIS

Maximum Simultaneous Draw:

Arduino (WiFi TX): 100mA

Motor (stall): 1200mA

Servo (stall): 300mA (60mA @ 12V via LM2596)

Sensors (all active): 45mA @ 5V

Pixy2 (LED on): 180mA @ 5V

PEAK CURRENT: ~1400mA @ 12V (15.5W)

Battery C-Rating Check:

- Required: 1400mA ÷ 2200mAh = 0.64C
- Typical LiPo: 20C capable
- **Battery can easily handle peak loads**

CONCLUSION

11.1V 2200mAh Battery Performance:

- **Adequate Capacity**: 2.94 hours typical runtime
- **Sufficient Current**: Can deliver 1.4A peaks easily
- **Good Voltage Stability**: Maintains >10V for 90% of discharge
- **Safety Margin**: 20C rating >> 0.64C required

The 11.1V 2200mAh battery is **well-suited** for this application, providing nearly 3 hours of runtime with comfortable current delivery margins. For competition use, this allows multiple runs with battery to spare.