Advancing -60 °C Lithium-Ion Battery Technology for Lunar and Deep Space Missions: KULR ONE Space (K1S) Pathfinder with TSC SEARF

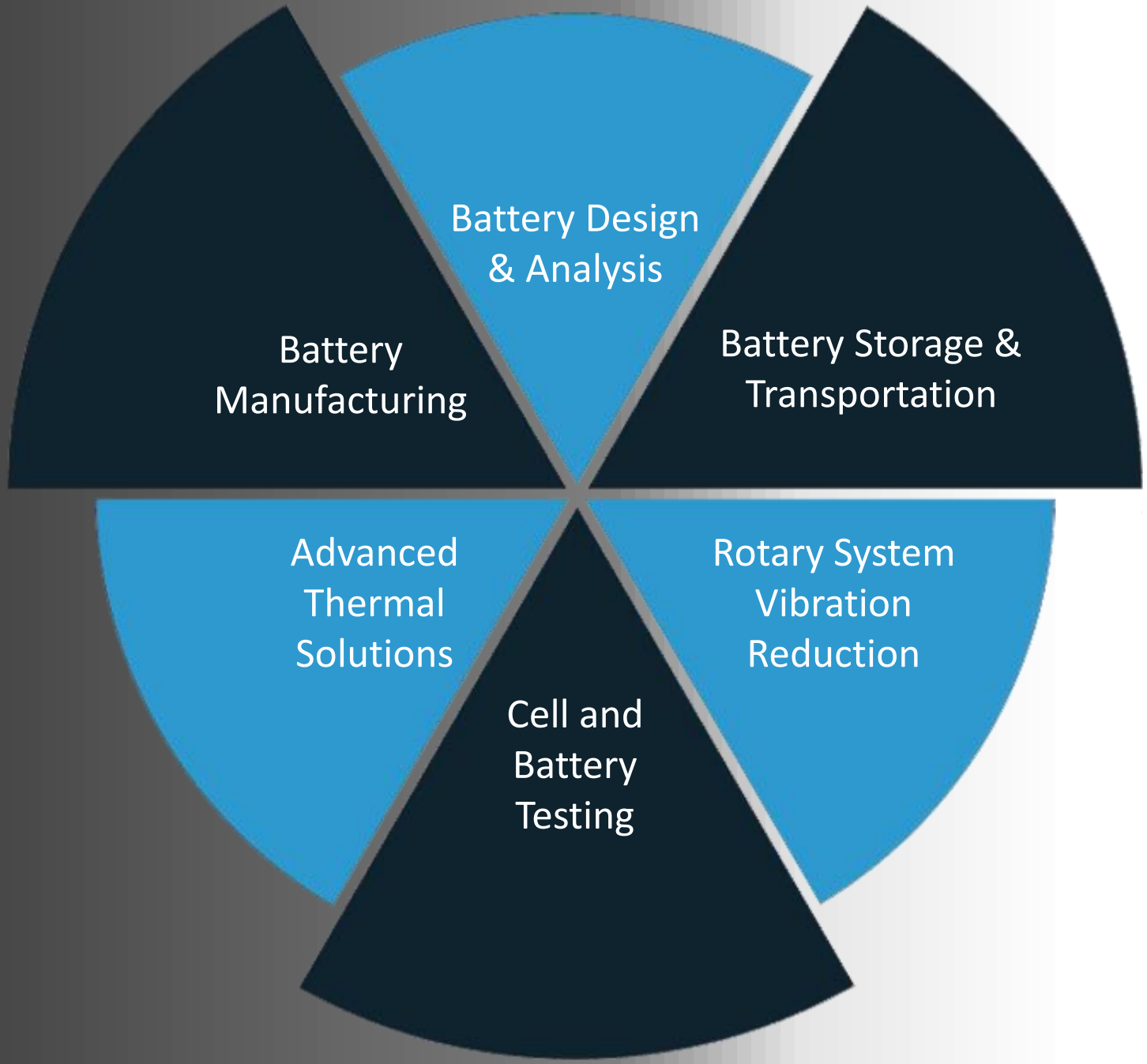
KULR Technology
A.J. Sauter

KULR

Key Technology Domains

Core engineering technology domains across **space**, **defense**, and **aerospace**.

We offer an extensive product and service portfolio designed to support all aspects of these core engineering technology domains.



SEARF Program

Mission Objective

Develop a high-energy-density lithium-ion battery pack for space, ensuring reliable performance at -60°C and in extreme thermal, vacuum, and radiation conditions, with a flight quality battery module integrated into a spaceflight mission in 2027.

1 Li-Gas Chemistry

South8 Technologies LiGas® Cell

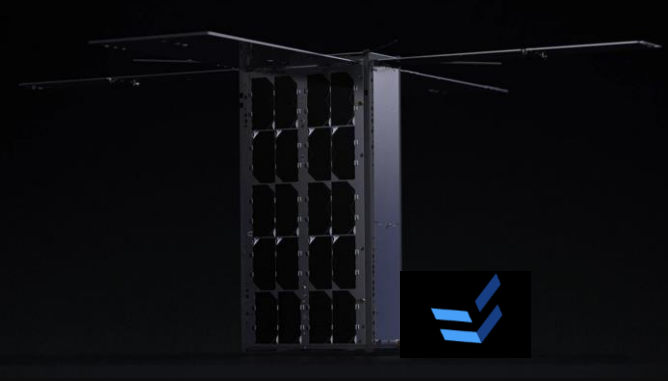
Operating Temperature: -60°C to 60°C
Cell Characterization: KULR, NASA, ESRF, SWRI
OEM Engagement: Nominal & ISC JRs
KULR to down-select: 18650 vs. 21700

2 PPR-Rated Design

KULR Technology Battery Assembly

Requirements: JSC 20793 D
Gravimetric Energy Density: 100 Wh/kg
Product: KULR ONE® SPACE, 4S-8S, 1P-2P
Features: Li-Gas Cells, Space-rated BMS

3 Mission Profile



EnduroSat 8U CubeSat Hardware

Launch Provider: ExoLaunch
Launch Window: November 2027
Mission: SpaceX Transporter 22 (T-22)
Payload: K1S Battery, Telemetry & Live-feed

Lunar and Deep Space Missions

Lunar Environment

Thermal: -233°C to 125°C
Vacuum: 10^{-8} Torr to 10^{-12} Torr
Radiation: 20 krad to 100+ krad

Deep Space Environment

Thermal: -269°C to 200°C
Vacuum: 10^{-17} Torr
Radiation: 300 krad

Cell Specifications

18650-Format V1 Hardware

Nominal Capacity	3.50 Ah
Nominal Voltage	3.60 V
Maximum Voltage	4.20 V
Minimum Voltage	2.50 V
Charge Current	1.70 A
Standard Discharge Current	3.50 A
Maximum Discharge Current	10.0 A
Charge Temperature	-20°C to 60°C
Discharge Temperature	-60°C to 60°C
Storage Temperature	-60°C to 60°C

21700-Format V1 Hardware

Nominal Capacity	5.10 Ah
Nominal Voltage	3.65 V
Maximum Voltage	4.20 V
Minimum Voltage	2.50 V
Charge Current	1.50 A
Standard Discharge Current	2.50 A
Maximum Discharge Current	7.50 A
Charge Temperature	-20°C to 60°C
Discharge Temperature	-60°C to 60°C
Storage Temperature	-60°C to 60°C

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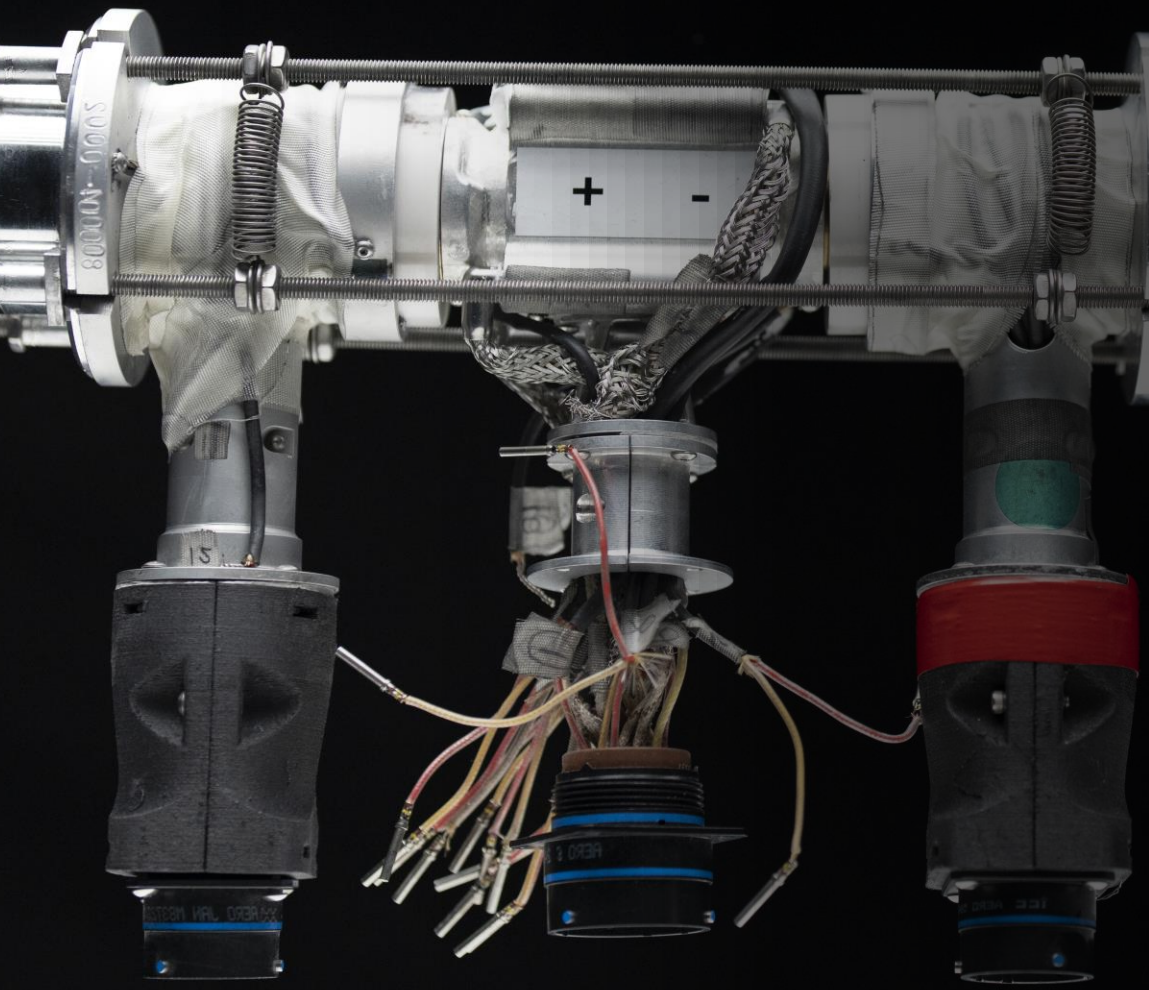
Cell & Pack Characterization Testing



Abuse Testing:

- Fractional Thermal Runaway Calorimetry
- European Synchrotron Radiation Facility
- Impingement Zone Mapping
- Adiabatic Bomb Calorimetry
- Cell Level Abuse Testing
- Pack/Module Abuse Testing
- Gas Analysis (SwRI)
- Particle Size Analysis (SwRI)
- Vent/Burst Pressure Testing (JSC)
- Blast Plate Testing (JSC)

Electrical Testing:

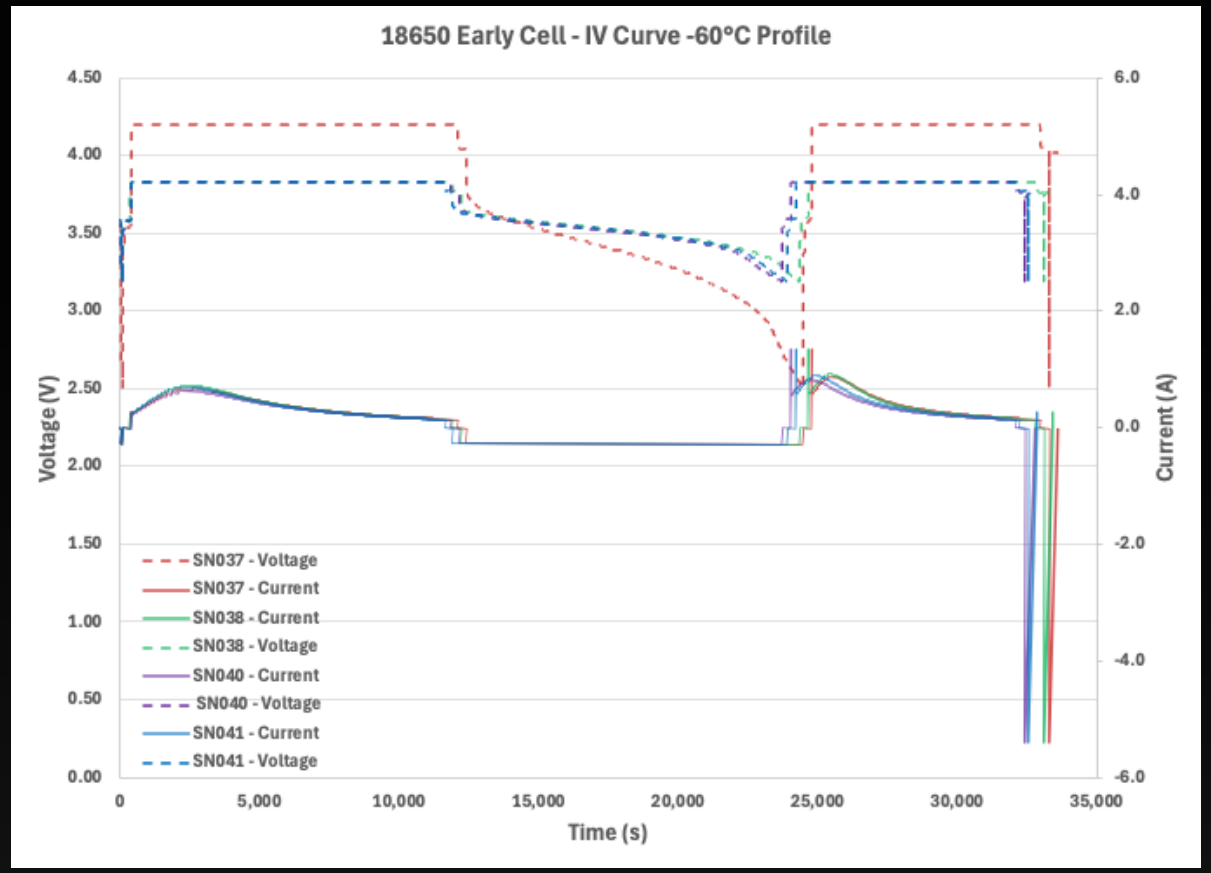
- Cell Cycling
- Module Cycling
- Cycle Life Testing (JPL)

Environmental Testing

- Thermal Vacuum
- Thermal & Humidity
- Vibration
- Isothermal Calorimetry
- Extreme-Cold Exposure (GRC)

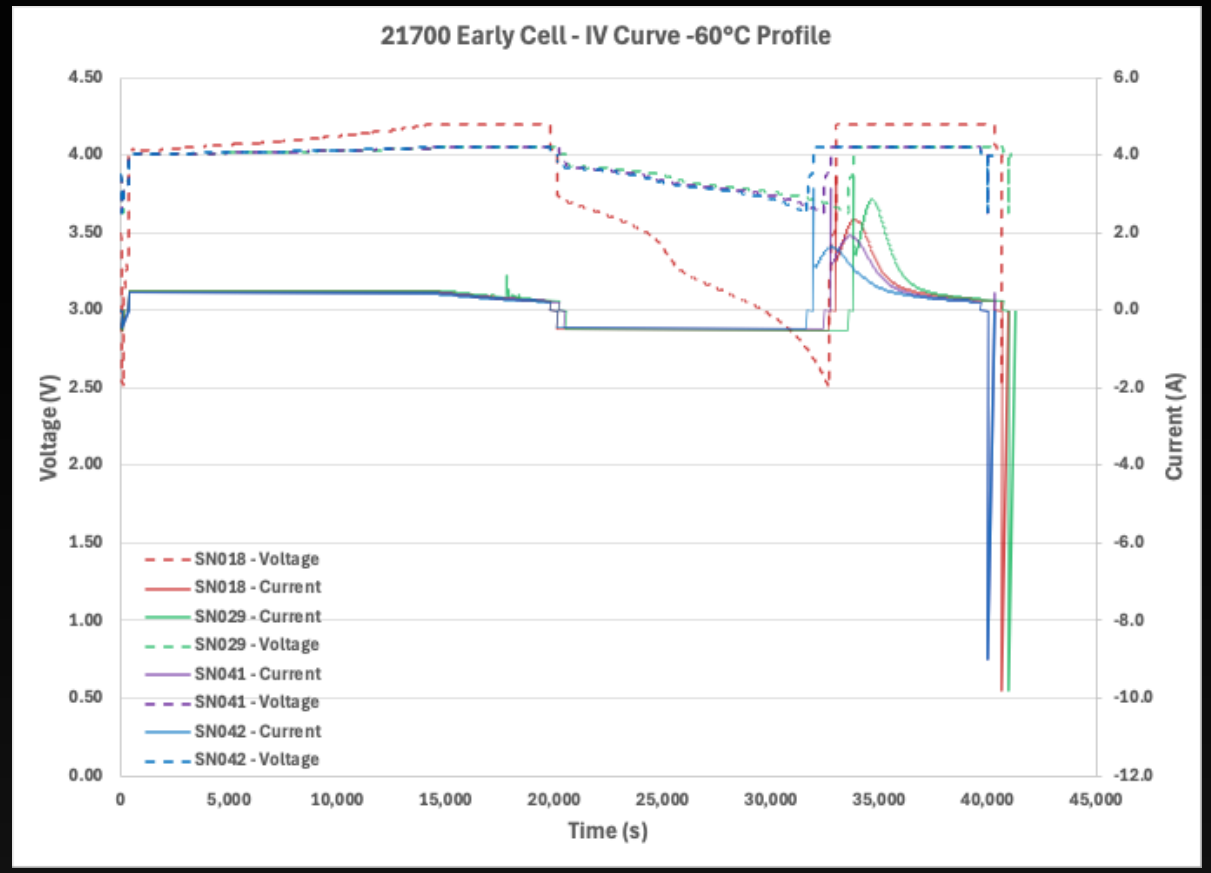
Early Cell Thermal Performance

18650-Format ”Early” Cell



Retention (at C/10): **33.2% Nominal Capacity**

21700-Format “Early” Cell



Retention (at C/10): **34.4% Nominal Capacity**

Early Cell Abuse Testing

Impingement Zone Mapping

- Mixture of heater and heater max power tests did not enter TR for both Li-Gas cell formats.

Bomb Calorimetry

- Heat-Wait-Seek (HWS)
- Vent as early as 91.6°C
- No TR for 9 of 10 Li-Gas Cells

Fractional Thermal Runaway Calorimetry

Type	Capacity (Ah)	EY Averages (kJ)				CB%				Pos %				Neg %			
		Nail	*Heater 5-10*	*Max Power*	*Total*	*Nail*	*Heater 5-10*	*Max Power*	*Total*	*Nail*	*Heater 5-10*	*Max Power*	*Total*	*Nail*	*Heater 5-10*	*Max Power*	*Total*
Control 18650	3.5	79.90	77.29	74.20	77.13	24.27	12.72	15.92	17.64	75.2	86.54	83.09	81.6	0.5	0.74	0.99	0.8
"Early" 18650	2.7	52.17	46.49	50.04	49.56	35.25	19.22	12.98	22.48	0.60	1.64	1.19	1.15	64.13	79.16	85.85	76.38
Control 21700	5.0	109.37	100.17	94.36	101.30	29.31	20.01	10.21	19.84	70.03	66.34	87.89	74.75	0.68	13.68	1.90	5.42
"Early" 21700	5.1	109.27	99.87	105.50	104.88	23.47	11.57	6.61	13.89	0.67	0.79	0.78	0.75	75.85	87.65	92.61	85.37

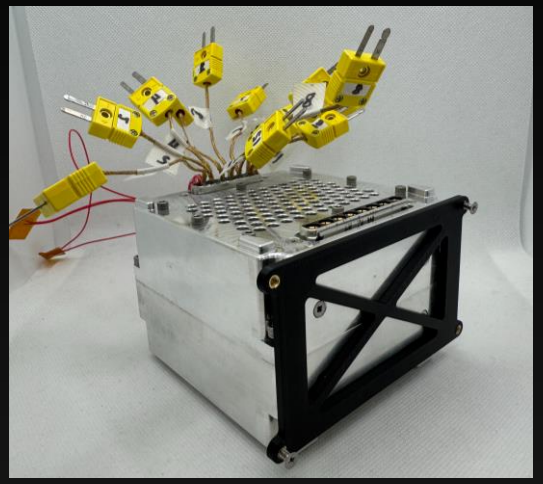
PPR Pack Design

Engineering Design Unit (EDU)

18650 Battery Design

Electrical Specifications	
Configuration	4s2p
Nominal Capacity	5.40 Ah
Nominal Voltage	14.4 V
Maximum Voltage	16.8 V
Minimum Voltage	10.0 V

18650 EDU

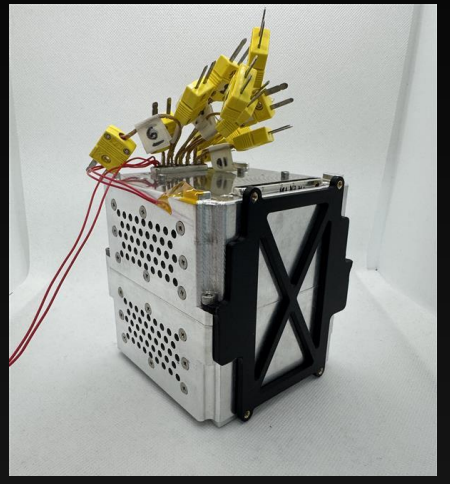


Physical Specifications	
Mass	1.05 kg
Dimensions	98 x 98 x 77 mm
Power Connector	8-pin D-Sub
Data Connector	25-pin D-Sub

21700 Battery Design

Electrical Specifications	
Configuration	4s2p
Nominal Capacity	9.80 Ah
Nominal Voltage	14.4 V
Maximum Voltage	16.8 V
Minimum Voltage	10.0 V

21700 EDU



Physical Specifications	
Mass	1.63 kg
Dimensions	98 x 98 x 112 mm
Power Connector	8-pin D-Sub
Data Connector	25-pin D-Sub

Mission Profile

Low-Earth Orbit (LEO)

- Launch: November 2027
- Operation: 1-year Mission
- CubeSat Size: 8U
- K1 SPACE Battery Payload: ~1U
- Load Profile: 50% Visual Ops Payload, 50% CubeSat

KULR

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