Temasek Defence Systems Institute

USB-C POWER DELIVERY FOR MILITARY PORTABLE SYSTEMS

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Introduction & Motivation

Operational Challenge

- Modern soldiers rely on multiple portable electronics: radios, NVGs, GPS, tablets, medical devices.
- Each device uses a **proprietary battery + charger**, creating a **fragmented power ecosystem**.
- For a 72-hour mission, a soldier may carry **20 - 40 lbs of batteries** across **8+ types**.
- This weight, redundancy, and incompatibility **increase logistical burden** and risk mission downtime.

Need for Standardization

- <u>Current approach</u>: heavy, inefficient, and incompatible across coalition partners.
- NATO STANAG 4695 and U.S. DoD initiatives show push for **common soldier power standards**.
- <u>Opportunity</u>: leverage **commercial USB-C Power Delivery (PD)** as a **universal charging interface**.

Research Motivation

- Can USB-C PD reduce **charger count**, **improve readiness**, and **lighten soldier load**?
- This study explores USB-C PD adoption via **prototype testing** and **system-wide analysis** to demonstrate its potential as a **unified power solution** for military portable systems.

Research Objectives

Prototype Development

Design and test two USB-C PD-enabled battery packs:
(1) 4S1P : mid-power devices (radios, tablets, NVGs).
(2) 4S3P : high-power devices (laptops, ISR, medical).

Empirical Evaluation

Assess charge time, discharge performance, capacity retention, and thermal response under varied load profiles.

Adoption Analysis

- Build dataset of 73 military devices to compare legacy vs USB-C PD performance.
- Quantify time savings (%) and availability improvements (%).

Operational Simulation

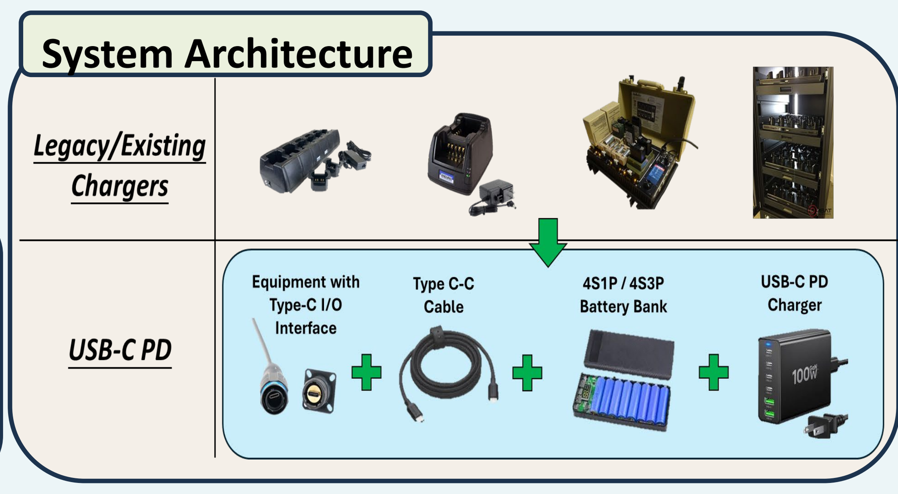
Use squad-level tool to estimate total charger count, mission readiness, and logistics impact.

Methodology

Prototype Development

- Built two USB-C PD battery prototypes:
4S1P → mid-power devices (radios, tablets, NVGs).
4S3P → high-power devices (laptops, ISR, medical).
- Embedded in rugged enclosures (RF-10, CY-8523B).

System Architecture



Testing Approach

- Evaluated under light, medium, heavy load profiles (0.8 - 4.5 A).
- <u>Key metrics</u>: charge/discharge time, capacity retention, thermal response, power negotiation stability.

Adoption Analysis

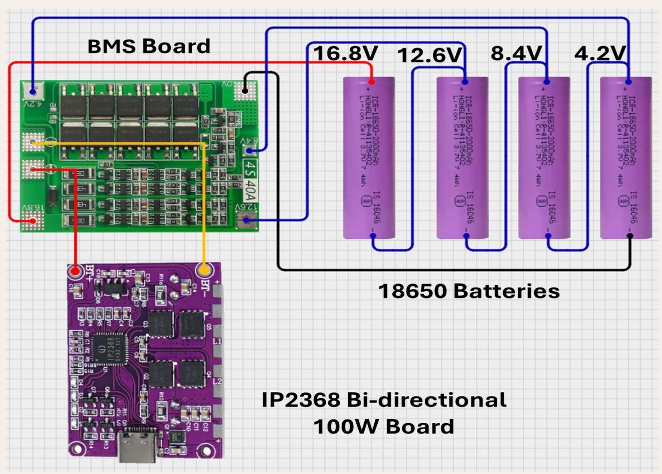
- Dataset of 73 devices across C2, ISR, medical, and soldier systems.
- Developed time savings (%) and availability (%) metrics.
- Built regression model to predict benefits.
- Created Squad Simulation Tool to estimate charger count, mission readiness, and logistics impact.

Results

Prototype Configurations and Testing

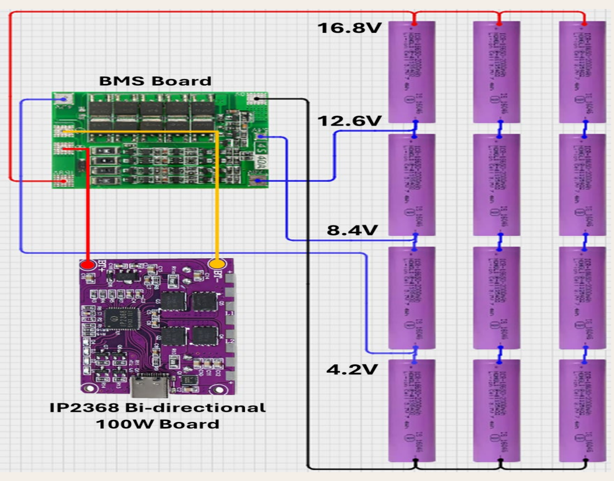
4S1P Schematic

Designed for mid-power systems (<70 Wh). Optimized for compact form factor and low weight while maintaining full compliance with USB-C PD profiles up to 20 V.



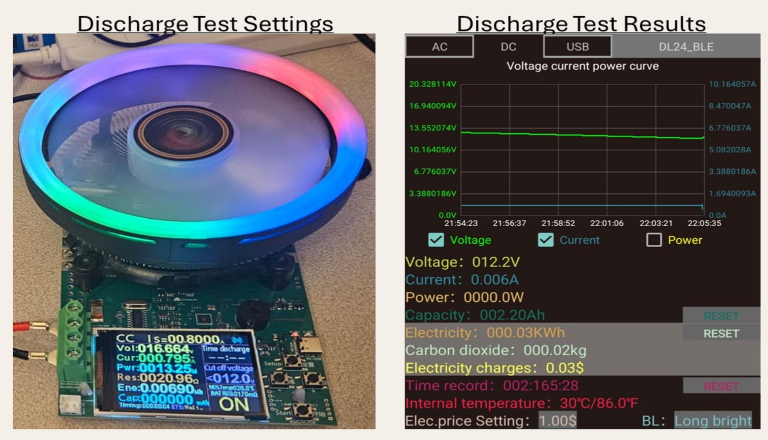
4S3P Schematic

High-capacity design supporting power delivery >70 Wh. Intended for laptops, ISR payloads, and portable medical equipment.



Load Testing of Prototypes

Tiered constant current tests on the 4S1P and 4S3P prototypes under light, medium, and heavy loads showed stable discharge, safe thermal response, and a 70 - 80% reduction in charge time compared to legacy chargers.



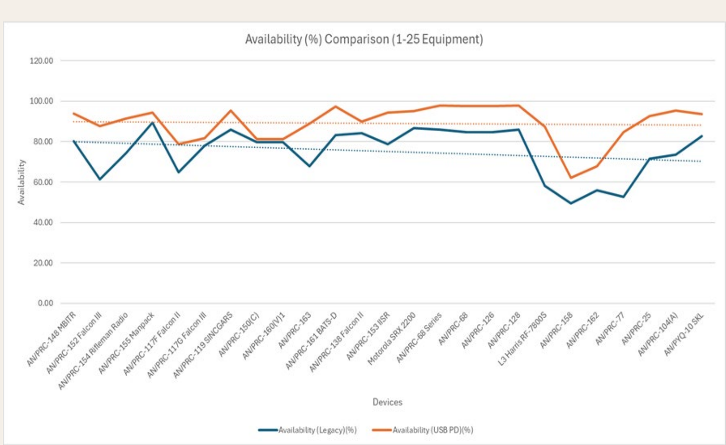
Demonstration of Field Use

4S3P prototype in a CY-8523B enclosure successfully charged a laptop, while the 4S1P prototype in an RF-10 enclosure powered a handheld device.

Adoption Analysis Findings

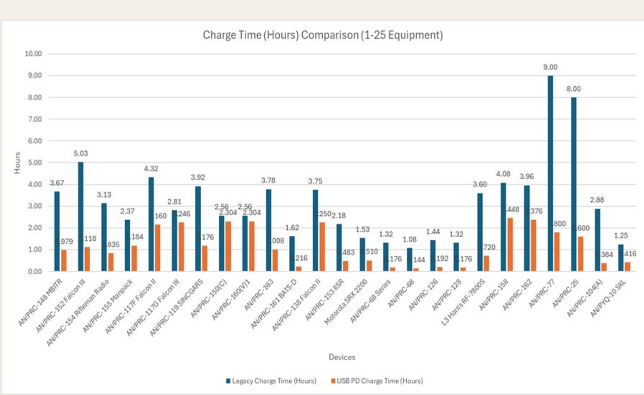
Availability Gains

Across the 73-device dataset, USB-C PD improved readiness by 10–15%, reducing downtime due to prolonged charging.



Time Savings

Larger-capacity devices (>70 Wh) showed the greatest improvements, but consistent benefits were observed across all device classes.



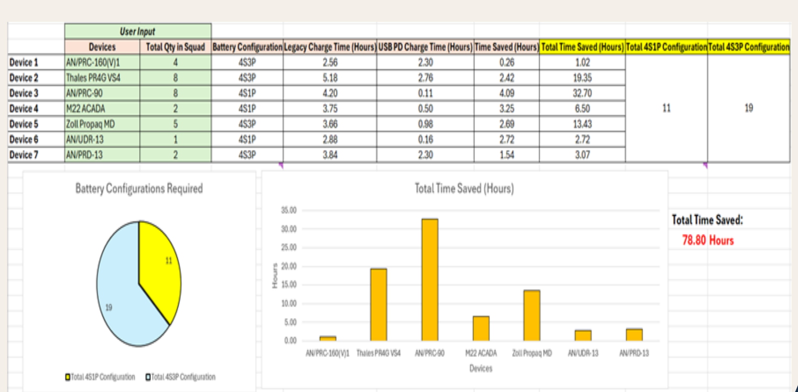
Regression Model

High explanatory power ($R^2 > 0.86$) confirmed predictive validity, enabling estimation of USB-C PD benefits for untested devices.

Summary Output			
Regression Statistics		ANOVA	
Multiple R	0.927571546	F-statistic	141.7434344
R Square	0.860388973	Significance F	1.97E-29
Adjusted R Square	0.854318929	Coefficient for T_{legacy} (hr)	7.044866466
Standard Error	8.394184082		
Observations	73		
Multiple R	0.927571546		

Squad-Level Simulation

Results demonstrated significant reductions in chargers required, several hours saved in cumulative charging time, and higher mission readiness in a 72-hour mission cycle.



Conclusion & Future Work

Conclusion

- USB-C PD improves charging efficiency, interoperability, and readiness.
- Prototypes validated **70–80% faster charging** with safe operation.
- Dataset of 73 devices showed **~73% time savings**, confirmed by regression and squad-level simulations.
- Establishes USB-C PD as a scalable solution for military portable power.

Limitations

- Findings based on controlled lab tests; real-world performance not yet validated.
- Thermal constraints under prolonged high-power (4.5 A) operations.
- USB-C connectors not yet fully ruggedized to MIL-STD/IP68.Dual use of USB-C (power + data) introduces cybersecurity risks.

Future Work

- Develop rugged MIL-STD connectors.
- Implement secure power-only protocols.
- Align with microgrid and renewable energy strategies.

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