ENGINEERING NOTE · CUSTOM HARDWARE

Custom Rugged Multi-Bay Battery Chargers in 2026: From Spec Sheet to Engineering Samples in 16 Weeks

A catalogue rugged charger rarely fits a new battery, and the makers of custom ones seldom publish lead times or prices. This is a sealed, fanless multi-bay charger platform that goes from a specification to working engineering samples in 16 weeks: how it is built, how the gaps in a specification get filled, how development is staged, and what to send if you need one.

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Abstract

A rugged multi-bay charger is a low-volume product built around someone else's battery, which is why most of them end up custom. This note describes a platform for building them quickly. It is a sealed, fanless aluminium case with swappable battery adapter plates, one isolated charge channel per bay on a shared 48 V bus, AC and 24 V vehicle inputs with AC priority, and every battery-specific parameter kept in firmware tables. The worked example has four bays, 120 W, 14.3 litres and about 5 kg; the same design covers two to eight bays. Once the specification and sample batteries are in hand, a fixed-price first phase delivers three engineering samples, a test report and a full compliance matrix in 16 weeks; a second phase freezes the design and prepares qualification, after which the complete design data package is handed over. Building in Shenzhen, the home city of two of China's largest battery makers and a short drive from almost every part, is what makes that schedule and the price possible.

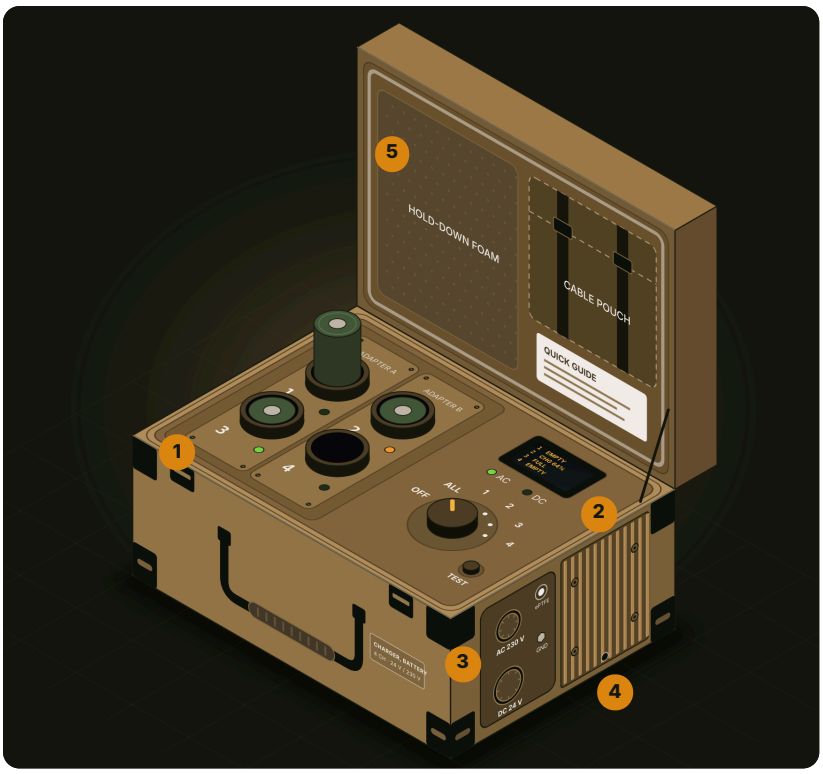
Why I wrote this

Every few weeks someone needs a charger for a battery that nobody else charges: a radio battery with its own data line, a drone pack with a custom connector, a 24 V vehicle where the charger has to ride through engine starts. The big defence suppliers' catalogue chargers fit their own batteries. The custom-charger makers I found describe their capabilities but not their lead times or their prices. I designed this platform so that a custom charger can be scoped in days and sampled in weeks, and I am writing it up so that anyone with such a battery knows what to send and what to expect. Every number below is as of November 2026, and money is in US dollars.

Results at a glance

Figure 1. One platform, configured per program: the four-bay version, with the same case in three finishes.

The four-bay configuration in desert tan, lid open. The same case comes in olive drab, black or a color to order.



1. **Swappable adapter plates**
   Two wells each; a new battery means a new plate, not a new case
2. **Display, selector, TEST**
   All bays at a glance or one bay in detail; built-in test on demand
3. **AC and vehicle inputs**
   AC takes priority; vehicle input built for MIL-STD-1275
4. **Finned end wall**
   The sealed, fanless electronics bay sheds heat through it
5. **Lid pad and cable pouch**
   Holds the batteries in place with the lid closed

FINISHES



Desert tan | Olive drab | Black

Source: The author's concept design, revision 2.1, November 2026.

	Platform range	Four-bay example
Bays	2 to 8, identical and galvanically isolated	4
Charge power	About 60 to 300 W in total	120 W, 9 A in total, all bays at once
Batteries	Li-ion, Li-polymer and $LiFePO_4$, 1 to 14 cells in series per bay	Four 99 Wh packs in about 4 hours
Battery data	Isolated SMBus or one-wire port per bay: read capacity and cycle count, write with the battery's interface document	Read and write
Inputs	90–264 VAC, 47–63 Hz; 12 or 24 V vehicle DC with MIL-STD-1275 transients; AC takes priority, seamlessly	230 VAC and 24 VDC
Controls	OLED rated to −40 °C, a two-color LED per bay, a selector (OFF, ALL, one position per bay) and a sealed TEST button; text in any language, right-to-left included	Six positions
Case	Welded 5052 aluminium, IP67 electronics bay, no fan, lid closed in motion; olive drab, desert tan, black or a color to order	340 × 240 × 175 mm, 14.3 L, about 5.1 kg
Environment	Operate −20 to +55 °C, store −40 to +71 °C	Same
Designed to	MIL-STD-810H, 461G, 1275E and F, IEC 62368-1:2023; reports can cite older method numbers	Same
Schedule	16 weeks to three engineering samples, about 30 weeks to pre-qualification units	Same

What it is for

The platform is aimed at batteries that are carried, mounted or fielded in numbers, where a charger has to live in a vehicle, a shelter or a field case rather than on a desk:

- **Military and security radios.** Manpack and handheld batteries with data lines, from BB-2590-class packs to handheld radio batteries, where the charger reads the battery's memory and keeps its cycle count.
- **Drone and UAS fleets.** Field charging cases that charge four to eight packs at once from a vehicle, a generator or the grid.
- **Two-way radio fleets.** Public safety, mining, utilities and emergency response, where gang chargers ride in trucks and get dropped.
- **Vehicles and boats.** 24 V military and commercial vehicles, where the input has to survive engine starts, surges and reversed leads.
- **Industrial and test equipment.** Instrument and tool batteries that need a sealed, repeatable charger with a log.

Catalogue chargers fail these cases in predictable ways: the battery's contacts and latch are specific to it, the data protocol differs, the input does not match the vehicle, the case is too big, or the standards are not covered. A custom charger fixes all of that, but only if it can be designed without starting from a blank page every time. That is the point of the platform.

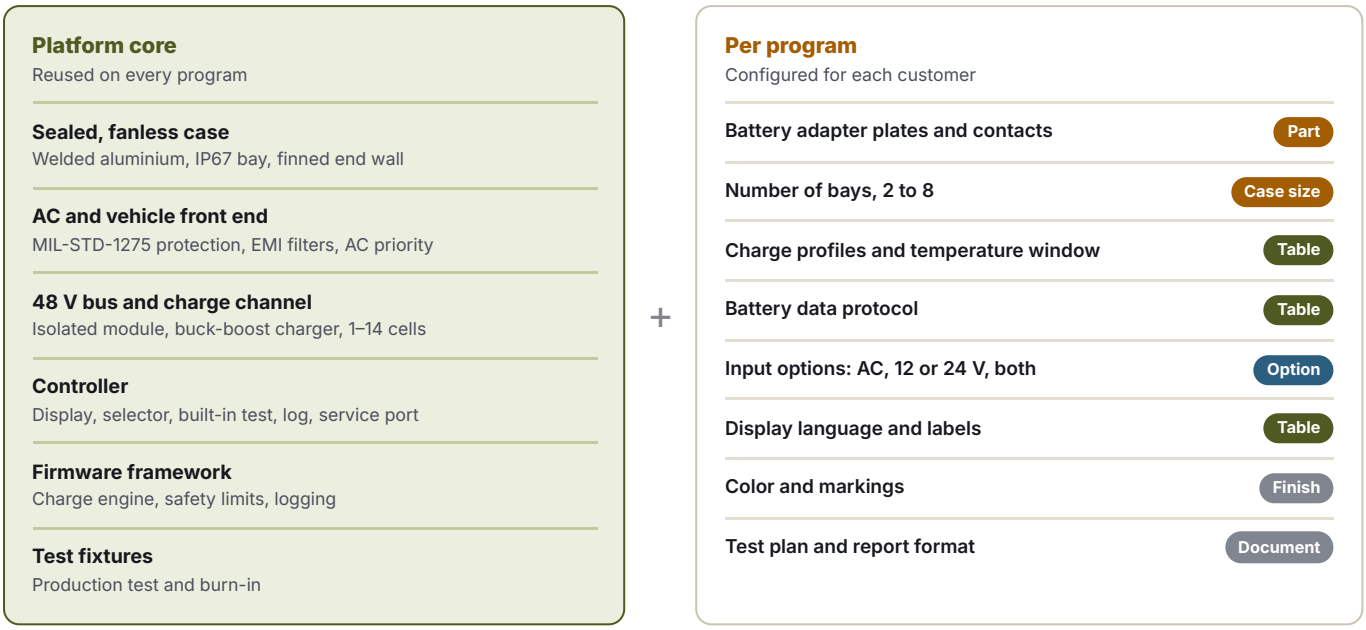
Step 1: turn the spec sheet into a design envelope

Specifications for rugged chargers are rarely complete. The usual gaps are the exact battery model, and with it the voltage, capacity, chemistry and contacts; whether "four hours" means one battery or four at once; whether "120 W" is input or output; which revision of each standard applies; what "EMP protection" means; and how the battery's memory is read and written. Waiting for every answer would stall the project for months.

Instead, I fill each gap with its most likely value, a confidence level and the margin the design needs if the guess is wrong, and then design an envelope that covers every plausible answer. In the four-bay example, three different batteries fitted the specification; one design envelope covers all three. Anything likely to be confirmed late lives in firmware tables: charge profiles, battery protocols, the selector's positions and every displayed string. A late answer then changes a configuration file, not the hardware.

Figure 2. What is reused on every program, and what is configured for each one.

The core carries the hard engineering once. A new battery or customer changes parts, tables and documents around it.



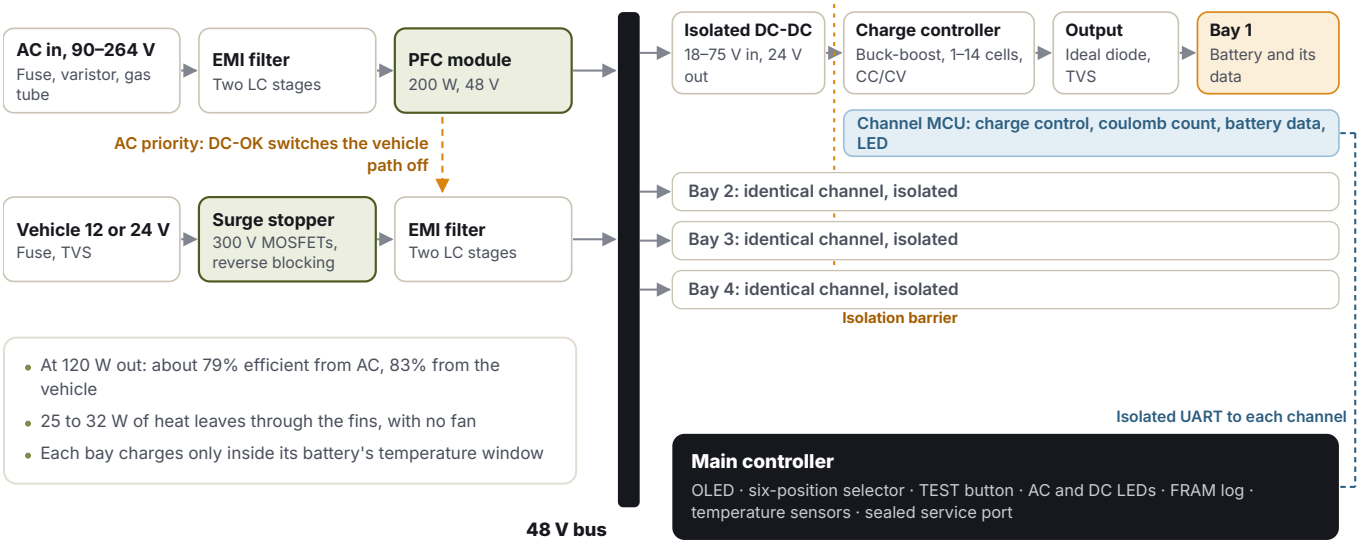
A late answer from the customer changes a table or a plate, not the hardware.

Source: The author's platform design.

Step 2: the electrical architecture

Figure 3. Two inputs, one 48 V bus, four isolated channels and a controller that talks to each over an isolated link.

The four-bay charger's electrical architecture. Every bay is identical; a fault in one leaves the others charging.



Source: The author's design.

The AC path runs through a fuse, a varistor and a gas discharge tube, a two-stage LC filter and a 200 W, 48 V power-factor-corrected module mounted on the case wall, then an ideal diode onto a 48 V bus. The vehicle path runs through a fuse, a TVS diode and a surge stopper with a 300 V MOSFET and back-to-back reverse-polarity blocking, then its own filter onto the same bus. When AC is present, the AC module's DC-OK signal switches the vehicle path off, so AC priority needs no relay and the changeover is seamless.

Each bay has an isolated DC-DC module (18–75 V in, 24 V out), a TI buck-boost charge controller that handles 1 to 14 cells with hardware constant-current and constant-voltage control, an output ideal diode and a TVS. A small microcontroller on each channel's isolated side runs the charge controller, counts coulombs, talks to the battery's memory and drives the bay's LED; it reports to the main controller over an isolated UART. The main controller runs the display, reads the selector and the TEST button, keeps the log in FRAM, watches the temperature sensors and owns a sealed service port.

The choices are deliberate:

- **Isolation between bays comes almost free,** because the isolated modules are there anyway; the digital isolators cost well under a dollar per channel.
- **A fault stays in its bay.** A shorted battery or a firmware fault in one channel leaves the other three charging.
- **Most of the EMI and safety risk sits in certified modules** with long field records, so development effort goes into integration, firmware and mechanics rather than into reinventing power supplies.
- **One stage of surge protection is enough,** because the channel modules tolerate 100 V for a second. The full front-end arithmetic is in my MIL-STD-1275, 810 and 461 checklist for battery chargers.

At 120 W of output, efficiency is about 79% from AC and 83% from the vehicle, so the case has to shed 25 to 32 W without a fan. The AC module derates above 50 °C, so at +55 °C in full sun the firmware trims charge power, or a larger module goes in where full power at that temperature is required. Each channel also measures its battery's temperature and charges only inside the battery maker's window, typically 0 to 45 °C: outside it, the bay pauses, flashes red and says why, then resumes by itself. Heater pads in the wells are an option for customers who must charge at −10 °C.

Step 3: the case

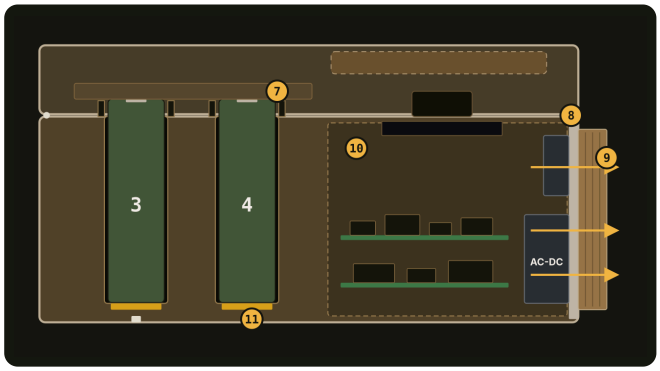
Figure 4. Plan and section: batteries on the left, the sealed electronics bay on the right, heat out through the finned end wall.

Plan and section of the four-bay case. Heat leaves through the finned end wall; the lid seals and holds the batteries.

PLAN



SECTION



1. **Two swappable adapter plates** — 2 × 2 battery wells at 70 mm pitch
2. **Two-color LED per bay** — Green full, amber charging, red fault
3. **2.42-inch OLED, −40 °C grade** — Capacity, cycle count, status, any language
4. **AC and DC indicators** — AC priority; DC takes over seamlessly
5. **Six-position selector, TEST button** — OFF, ALL or one bay; all bays always charge
6. **Gasket land** — The lid seals the full perimeter
7. **Lid foam pad** — Holds the batteries in their wells
8. **D-section silicone gasket** — Continuous; dust-tight and rain-tight
9. **Vertical fins** — Natural convection; fan-ready bosses
10. **Sealed electronics bay** — ePTFE vent; heat out through the fins
11. **Battery wells sized per battery** — Contact block at the base, drain valve

Source: The author's concept design, revision 2.1.

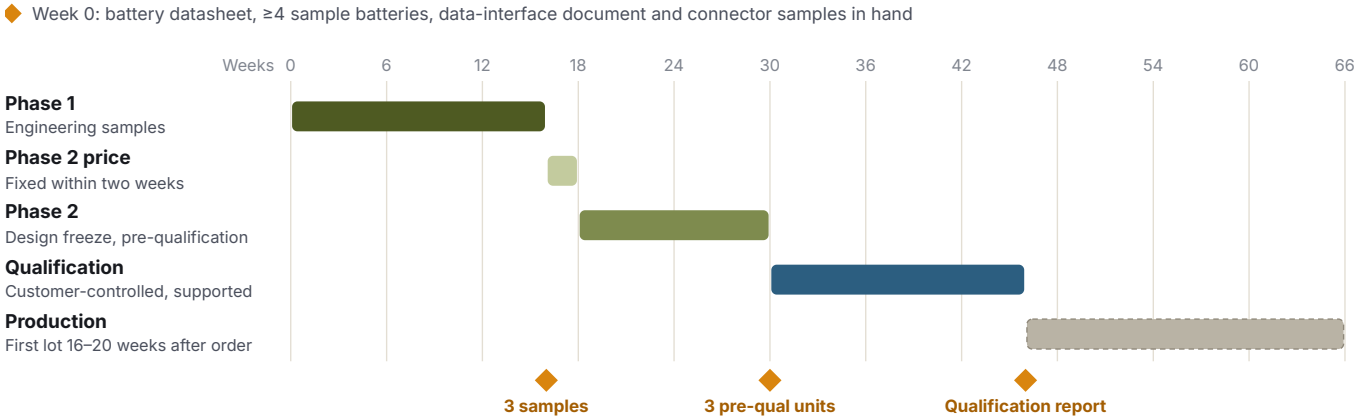
The case is welded 5052 aluminium with a sealed electronics bay at one end and the battery deck at the other. Every hot part conducts into a finned end wall, which sheds heat by natural convection; mounting bosses for a sealed external fan are there for programs that need more power at high temperature. An ePTFE vent lets the bay breathe at altitude without letting water in, and the battery wells drain through their own valves. The deck carries two swappable adapter plates with two wells each, so a new battery means a new plate and new contacts rather than a new case. A continuous D-section silicone gasket seals the lid, and a foam pad in the lid holds the batteries in their wells, so the charger can run with the lid closed in a moving vehicle. Polymer corner bumpers with strap slots take the drops, and the handle is sized for gloves.

The controls follow the same logic as the electronics. All four bays charge all the time: inserting a battery starts its bay, removing it stops it, and each bay has its own LED. The six-position selector powers the unit and chooses the view: OFF, ALL for a summary of every bay, or one bay at a time for its capacity in mAh and cycle count. Built-in test runs at every power-up and on demand from a sealed TEST button, and its results go into the log. A customer who wants to stop a single bay gets that in firmware, without adding a switch and a seal per bay.

Step 4: development in two fixed-price phases

Figure 5. Sixteen weeks to engineering samples, about thirty to pre-qualification units.

Weeks from the order, once the battery data and samples are in. Each phase has a fixed price.



Phase 1 delivers

- Three working engineering samples
- Test report: heat soak, 1275 surge, EMC pre-scan
- Compliance matrix: every requirement, design response and test

Phase 2 delivers

- Design freeze and three pre-qualification units
- One test plan for MIL-STD-810, 461 and 1275
- On payment: the complete design data package

Then

- Qualification run by the customer, with supplier support
- Production lots 16–20 weeks after an order
- Development cost credited against production units

Source: The author's development plan.

Development is split so that neither side bets the whole budget before seeing hardware.

Phase 1, 16 weeks, fixed price. The clock starts when the battery's datasheet, at least four sample batteries, the battery's data-interface document and connector samples arrive, normally within two weeks of the order. Phase 1 delivers three working engineering samples, a test report covering the risky items (heat soak, the MIL-STD-1275 surge, an EMC pre-scan) and a compliance matrix that answers every line of the specification with a design response and a verification method.

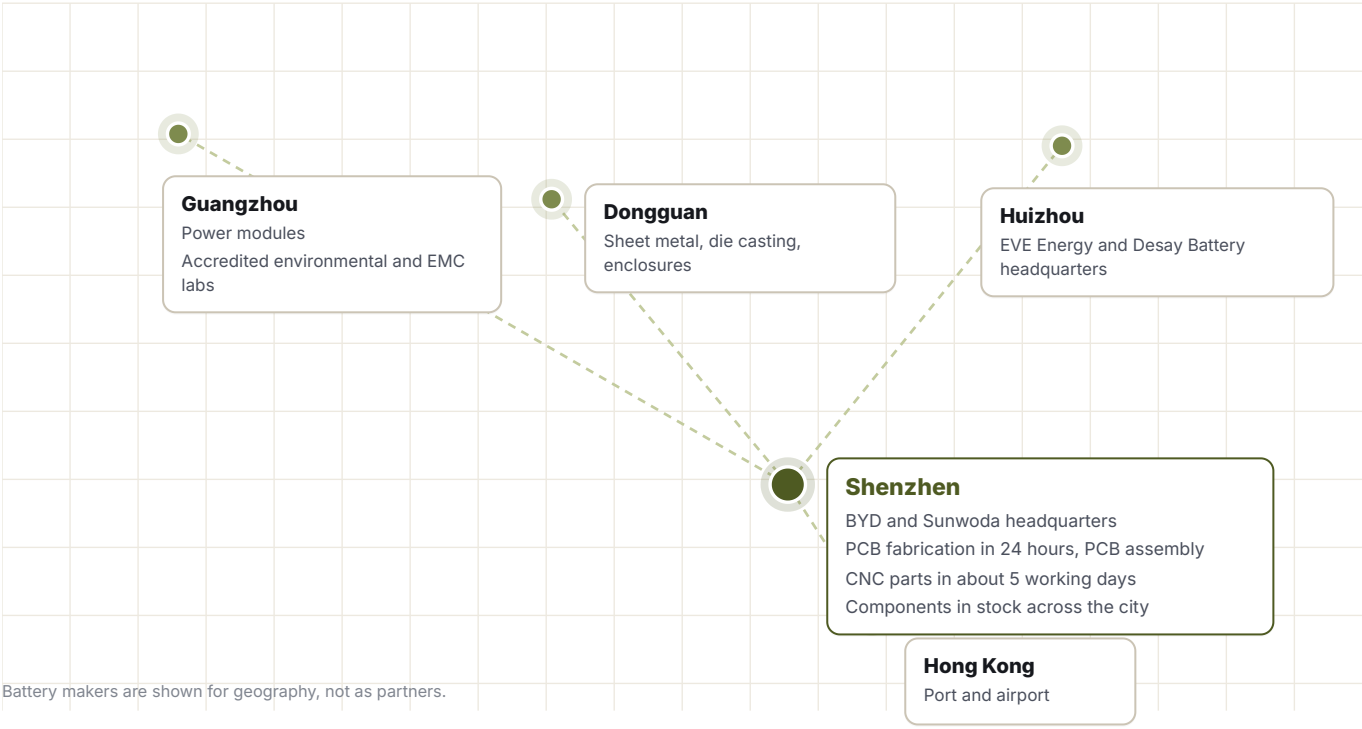
Phase 2, fixed price set within two weeks of Phase 1. Design freeze, pre-qualification units at about week 30 and a test plan covering MIL-STD-810, 461 and 1275 in one document. When Phase 2 is paid, the complete design data package changes hands: schematics, PCB files, firmware source, mechanical CAD, test procedures and a sourced bill of materials. The customer can then build the charger anywhere.

Qualification and production. Qualification is the customer's, with our test plan, pre-compliance data and corrective action behind it. Production lots follow 16 to 20 weeks after an order, and the development cost can be credited back against production units. What comparable military chargers sell for, and where a custom build lands against them, is in Multi-Bay Military Battery Charger Prices in 2026.

Why Shenzhen

Figure 6. Battery makers, boards, machining and test labs within a short drive of each other.

The Pearl River Delta around Shenzhen, schematic. Prototype loops take days because almost everything is local.



Battery makers are shown for geography, not as partners.

Source: Company headquarters from public company information; supply-chain lead times are typical Shenzhen figures, November 2026.

Speed and cost come from geography. Shenzhen is home to the headquarters of BYD and Sunwoda, and EVE Energy and Desay Battery are headquartered in neighboring Huizhou, so engineers who know lithium cells, battery management and their failure modes are never far away. A prototype board comes back in 24 hours, a machined part in about five working days, and almost every component is in stock somewhere in the city. Environmental and EMC labs with the accreditations a test report needs are in Shenzhen and Guangzhou. In practice that turns a design iteration from weeks into days, and it is a large part of why the platform can be priced well below what the incumbents charge. The battery makers are named for geography, not as partners.

What to send for a quote

A useful first email answers most of these, and the rest can follow:

- **The battery:** model and datasheet; sample batteries come later.
- **Bays:** how many, and how many must charge at once.
- **Power:** input sources (AC, 12 or 24 V vehicle, both) and the charge time you need.
- **Data:** what to read from or write to the battery's memory.
- **Environment and standards,** with revisions: temperatures, sealing, MIL-STD-810, 461, 1275, safety.
- **Limits:** size, weight, color and marking.
- **Quantities and dates:** prototypes, first lot, yearly volume and when you need samples.

Send it to i@tanshuai.com. I reply with the questions that decide the design and, once the battery is clear, a fixed price for Phase 1. If you are still writing your own specification, my design checklist for MIL-STD-1275, 810 and 461 shows which clauses drive cost.

Sources

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About the author

Tan Shuai is a technologist and founder with more than twenty years of work across chips, hardware and system software, and 20 granted patents. His work has taken him through Silicon Valley, New York, Chicago, Taiwan, the Greater Bay Area (Shenzhen and Hong Kong), Vietnam and Malaysia, with a long focus on advanced manufacturing and supply chains. Today he works as an AI researcher and developer, and builds custom rugged electronics with manufacturing partners in Shenzhen.

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